Emissions and Trends of Common Air Contaminants in Canada: 1970 to 1980

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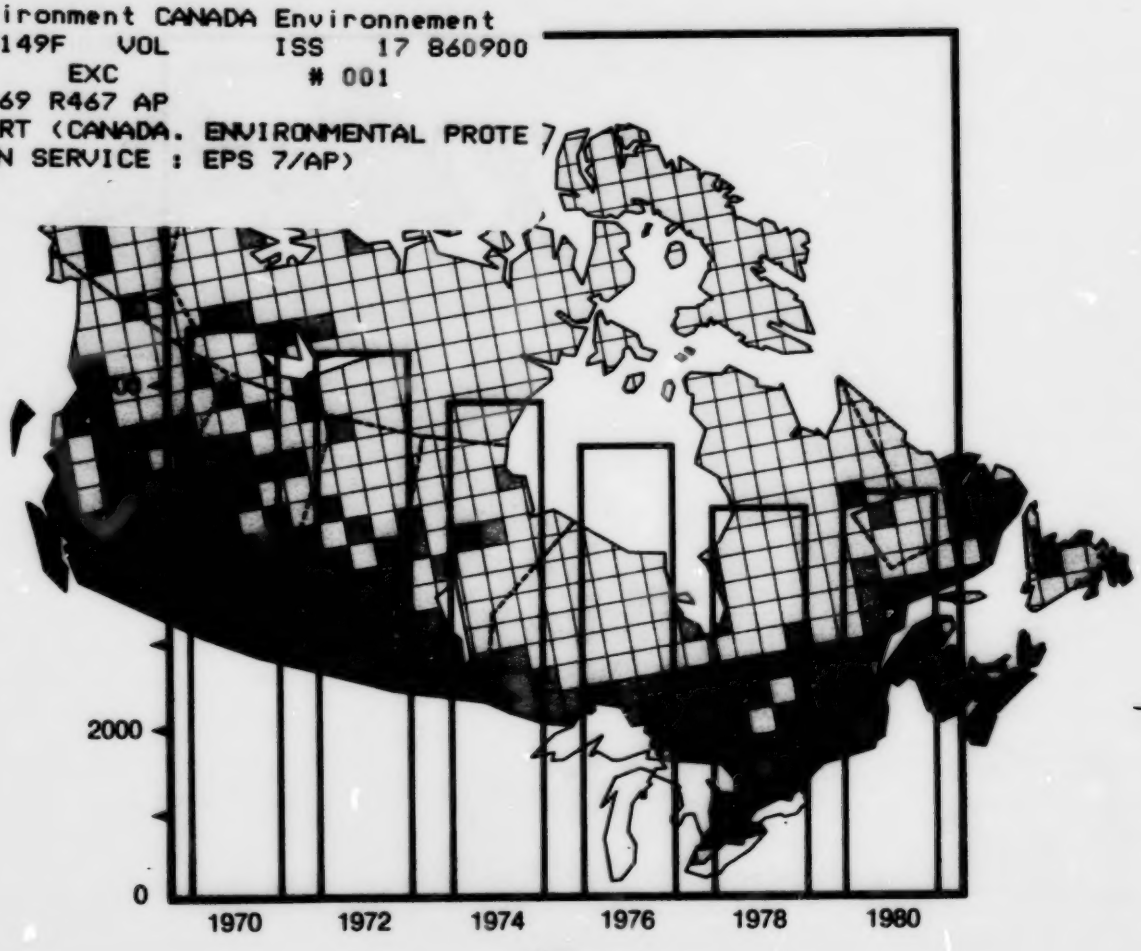

Sulphur Dioxide Emissions in Canada

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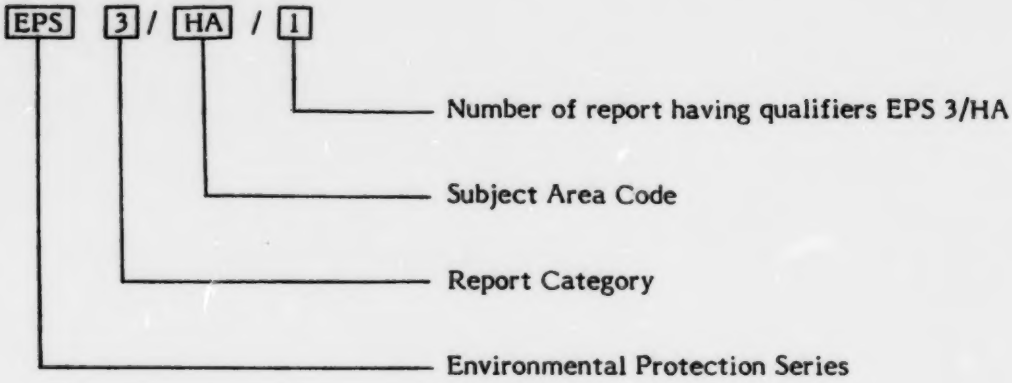

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NOTE: the cover is a representation of the emissions of sulphur dioxide spatially across the country (1980 emission density map) and over time (histogram).

EMISSIONS AND TRENDS OF COMMON AIR CONTAMINANTS IN CANADA (1970–1980)

Program Management Branch
Environmental Protection
Conservation and Protection
Environment Canada

Report EPS 7/AP/17
September 1986

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ABSTRACT

This report summarizes the 1980 annual emission estimates and trends from 1970 to 1980 for the five common air contaminants from anthropogenic sources. In 1980, 1.9 million tonnes of particulate were discharged to the atmosphere while gaseous emissions of sulphur dioxide, nitrogen oxides, hydrocarbons and carbon monoxide amounted to 4.7, 1.7, 1.9 and 10.3 million tonnes, respectively. The information is presented by province for approximately 85 sectors of the Canadian economy.

For the first time, an analysis of emission trends during the seventies is presented. Comparison of previous emission inventory publications for the seventies did not necessarily reflect emission trends because the changes in methodology resulting from improved data compilation and emission estimating methods affected the magnitude and quality of the emission estimates. By using the most accurate and consistent approach available to date, these emission estimates have been recalculated for previous years and reveal the following for the period between 1970 and 1980:

> "... particulate discharges to the atmosphere have decreased by 8% while gaseous emissions of sulphur dioxide, hydrocarbons and carbon monoxide have decreased by 31%, 2%, and 11%, respectively. Emissions of nitrogen oxides have increased by approximately 30%."

RÉSUMÉ

Les émissions des cinq principaux polluants atmosphériques produits par les activités humaines sont régulièrement inventoriées. Le présent rapport donne les résultats des évaluations faites pour l'année 1980 et présente pour la première fois une analyse des tendances des émissions pour les années 1970. On estime qu'en 1980, 1,9 million de tonnes de particules ont été rejetées dans l'atmosphère, alors que les émissions gazeuses d'anhydride sulfureux, d'oxydes d'azote, d'hydrocarbures et de monoxyde de carbone totalisaient 4,7, 1,7, 1,9 et 10,3 millions de tonnes, respectivement. Les données sont présentées par province et se rapportent à environ 85 secteurs de l'économie canadienne.

Une comparaison des données contenues dans les inventaires des émissions de polluants atmosphériques dressés pour les années 1970 ne permettait pas de dégager de tendances réelles, les méthodes d'évaluation des émissions et de compilation des données ayant été adaptées d'un inventaire à l'autre aux progrès réalisés dans ces domaines. On s'est servi ici de l'approche la plus pertinente et la plus cohérente dont on dispose à ce jour les évaluations des émissions pour les années antérieures ont été corrigées en fonction. Les conclusions tirées pour la période de 1970 à 1980 sont que

> "...les quantités de particules rejetées dans l'atmosphère ont diminué de 8 p. 100, tandis que les émissions gazeuses d'anhydride sulfureux, d'hydrocarbures et de monoxyde de carbone ont baissé respectivement de 31 p. 100, 2 p. 100 et 11 p. 100. Par contre, les émissions d'oxydes d'azote ont fait un bond de presque 30 p. 100."

TABLE OF CONTENTS

		Page
ABSTRACT		iii
RÉSUMÉ		iv
LIST OF TABLES		vi
LIST OF FIGURES		vii
1	INTRODUCTION	1
1.1	1980 Inventory	1
1.2	Summary	3
2	BASIC METHODOLOGY AND DATA SOURCES	12
2.1	Industrial Processes	12
2.1.1	Non-ferrous Smelters	12
2.1.2	Ferrous Industries	12
2.1.3	Mining and Mineral Processing	13
2.1.4	Wood and Paper Industry	14
2.1.5	Fossil Fuels Production	14
2.1.6	Chemical Industry	16
2.1.7	Other Manufacturing Industries	16
2.2	Fuel Combustion/Stationary Sources	17
2.3	Transportation	18
2.4	Solid Waste Incineration	20
2.5	Miscellaneous	20
3	EMISSION TRENDS	22
3.1	General Methodology	22
3.1.1	Industrial Processes	24
3.1.2	Fossil Fuels	25
3.1.3	Chemical Industry	25
3.1.4	Fuel Combustion/Stationary Sources	25
3.1.5	Transportation	25
3.2	Discussion	25
3.2.1	Particulate	26
3.2.2	Sulphur Dioxide	28
3.2.3	Nitrogen Oxides	32
3.2.4	Hydrocarbons	32
3.2.5	Carbon Monoxide	37
REFERENCES		40
APPENDIX A	1980 PROVINCIAL EMISSIONS BY SECTOR	47
APPENDIX B	EMISSION TRENDS	83
APPENDIX C	OPEN SOURCE EMISSIONS	95
APPENDIX D	1980 FUEL COMBUSTION EMISSIONS BY MAJOR FUEL TYPE	101

LIST OF TABLES

Table		Page
1	NATIONWIDE EMISSIONS OF AIR CONTAMINANTS (1980)	3
2	NATIONWIDE EMISSIONS OF AIR CONTAMINANTS, BY SOURCE (1980)	7
3	LIST OF SECTORS IN EMISSION TREND ANALYSIS	23
4	SUMMARY OF NATIONAL EMISSIONS (1970 to 1980)	26
5	PARTICULATE EMISSIONS BY CATEGORY	29
6	SULPHUR DIOXIDE EMISSIONS BY CATEGORY	30
7	NITROGEN OXIDE EMISSIONS BY CATEGORY	34
8	HYDROCARBON EMISSIONS BY CATEGORY	35
9	CARBON MONOXIDE EMISSIONS BY CATEGORY	39

LIST OF FIGURES

Figure		Page
1	DISTRIBUTION OF NATIONAL PARTICULATE EMISSIONS FOR 1980	4
2	DISTRIBUTION OF NATIONAL SULPHUR DIOXIDE EMISSIONS FOR 1980	4
3	DISTRIBUTION OF NATIONAL NITROGEN OXIDES EMISSIONS FOR 1980	5
4	DISTRIBUTION OF NATIONAL HYDROCARBON EMISSIONS FOR 1980	5
5	DISTRIBUTION OF NATIONAL CARBON MONOXIDE EMISSIONS FOR 1980	6
6	CHANGE IN DISTRIBUTION OF PARTICULATE EMISSIONS (1970 and 1980)	27
7	CHANGE IN THE DISTRIBUTION OF SULPHUR DIOXIDE EMISSIONS (1970 and 1980)	31
8	CHANGE IN THE DISTRIBUTION OF NITROGEN OXIDE EMISSIONS (1970 and 1980)	33
9	CHANGE IN DISTRIBUTION OF HYDROCARBON EMISSIONS (1970 and 1980)	36
10	CHANGE IN DISTRIBUTION OF CARBON MONOXIDE EMISSIONS (1970 and 1980)	38

1 INTRODUCTION

The purpose of this report is to identify and quantify sources of emissions to the atmosphere of the five primary contaminants for the year 1980 and to indicate what the emission trends of these contaminants were during the 1970's. The contaminants considered are: particulate matter, sulphur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide. Emissions are presented on a provincial and national basis.

This report updates (to 1980) the former publication "A Nationwide Inventory of Emissions of Air Contaminants, 1978" (Report EPS 3-EP-83-10). Direct comparison between the 1980 and earlier emissions data is not advisable because of improvements in methodologies; the addition of new sources; and the large variability of emissions from certain sources such as forest fires. Emission trends, however, are very important and a separate section of this report is devoted to them.

Emissions data have been compiled by Environment Canada on a biennial basis since 1970; therefore, the trends indicated are for the period 1970 to 1980. The emission estimates as they appear in the trends section are somewhat different from those quoted in previous nationwide inventory publications since all biennial emissions estimates were recalculated based on a standard methodology. This approach should, therefore, reflect the impact on emissions from such factors as economic activity, air pollution control, legislation, changes in energy demands by consumers, and trends in manufacturing activity.

1.1 1980 Inventory

In assessing air pollution on a national level, accurate data on the quantity and characteristics of emissions from all pollution sources are required. The large number of sources and the diversity of source types make it impractical to conduct emission testing on a source-by-source basis at the point of release.

As much information as possible has been extracted from replies to various questionnaires sent to individual companies over the previous few years. Where such firsthand data were not available, it was necessary to adopt the "emission factor" approach.

The emission factor is a statistical average of the rate at which a contaminant is released to the atmosphere as a result of some activity, such as combustion or industrial production, divided by the level of that activity. The emission factor, therefore, relates the quantity of each contaminant emitted to an appropriate "base" quantity such as production or quantity of fuel burned. The source of most emission

factors employed in this report is the "Compilation of Air Pollutant Emission Factors", published by the U.S. Environmental Protection Agency (1977) or from published supplements to this publication which indicate revised emission factors following a re-evaluation or additional testwork on specific emission sources. Where available, emission factors developed for Canadian conditions by the Environmental Protection Programs Directorate were used. Occasionally, only engineering estimates were available.

Information on production quantities and fuel consumption was usually obtained from either Statistics Canada or the Department of Energy, Mines and Resources. This was supplemented by data published by a number of industrial associations, and by information from other federal government departments, provincial government agencies, and industry.

Fugitive emissions are also included in the inventory. These emissions bypass off-gas containment and control equipment at industrial establishments and enter the atmosphere through no specific point, such as a stack. Fugitive emissions were not included in the nationwide inventories prior to 1978 since little information was available, and such emissions were considered to be insignificant. Only particulate fugitive emissions have been included here since little data exist on fugitive emissions for the other four contaminant categories.

Emissions have been estimated for each source type. Major sources were compiled on an individual basis and were aggregated to provincial totals while other point specific sources and area type sources were computed on a provincial basis. A summary of the sources of information used for the major categories of emission sources appears in Section 2.3.

Open sources have again been estimated for the 1980 inventory. These stationary sources emit air contaminants over large geographical areas, are diffused in nature, and cannot be controlled through enclosure or ducting (e.g., construction sites, agriculture erosion and tilling, paved and unpaved roads, tailing piles, forest fires, and landfills). Forest fires also emit significant amounts of nitrogen oxides and hydrocarbons in addition to particulate matter (Appendix C). These emissions are primarily of anthropogenic origin and should not be confused with natural sources of emissions. The emission estimates for these sources have a higher uncertainty than the conventional sources inventoried; however, published inventory techniques have been used.

The emission trends since 1970 are presented in Section 3. The biennial emission inventories were used as the starting point in the preparation of emission trends data. The results are indicated for the same major emission sources as for the 1980

inventory. The results are discussed on a contaminant basis and any changes within specific sectors that significantly affected emission rates are highlighted.

1.2 Summary

Atmospheric emissions of particulate matter, sulphur oxides, nitrogen oxides, hydrocarbons and carbon monoxide from various Canadian sources have been estimated for the year 1980. These sources represent 85 sectors of the Canadian economy and are grouped into five major categories:

1. Industrial sources,
2. Fuel combustion - stationary sources,
3. Fuel combustion - transportation,
4. Waste incineration, and
5. Miscellaneous.

Emission totals for the five major contaminants are presented in Table 1. In 1980, 1.9 x 10^6 t of particulate entered the atmosphere. Gaseous emissions of sulphur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide amounted to 4.7, 1.7, 1.9 and 10.3 x 10^6 t, respectively.

Figures 1 to 5 show the percentage contribution of each major category to the emissions of each contaminant. In Figures 1 and 2, industrial sources are shown to account for over 60% of the emissions of particulate matter and sulphur oxides. In Figures 3, 4 and 5, transportation sources are shown to contribute over 60%, 40% and 70% to the emissions of nitrogen oxides, hydrocarbons, and carbon monoxide, respectively.

TABLE 1 NATIONWIDE EMISSIONS OF AIR CONTAMINANTS (1980)

	Emissions (tonnes x 10^3)									
Category	Particulate Matter	% of Total	Sulphur Oxides*	% of Total	Nitrogen Oxides**	% of Total	Hydro-carbons	% of Total	Carbon Monoxide	% of Total
Industrial Processes	1 216	63.8	3 127	67.2	48	2.8	572	30.6	609	5.9
Fuel Combustion/ Stationary Sources	311	16.3	1 384	29.8	582	33.7	67	3.6	481	4.7
Transportation	98	5.2	137	2.9	1 072	62.2	797	42.6	7 776	75.6
Solid Waste Incineration	33	1.7	3	0.1	5	0.3	31	1.7	374	3.6
Miscellaneous***	248	13.0	-	-	18	1.0	403	21.5	1 053	10.2
TOTAL	1 906	100.0	4 651	100.0	1 725	100.0	1 870	100.0	10 293	100.0

* expressed as SO_2
** expressed as NO_2
*** refer to Table 2 for included sources

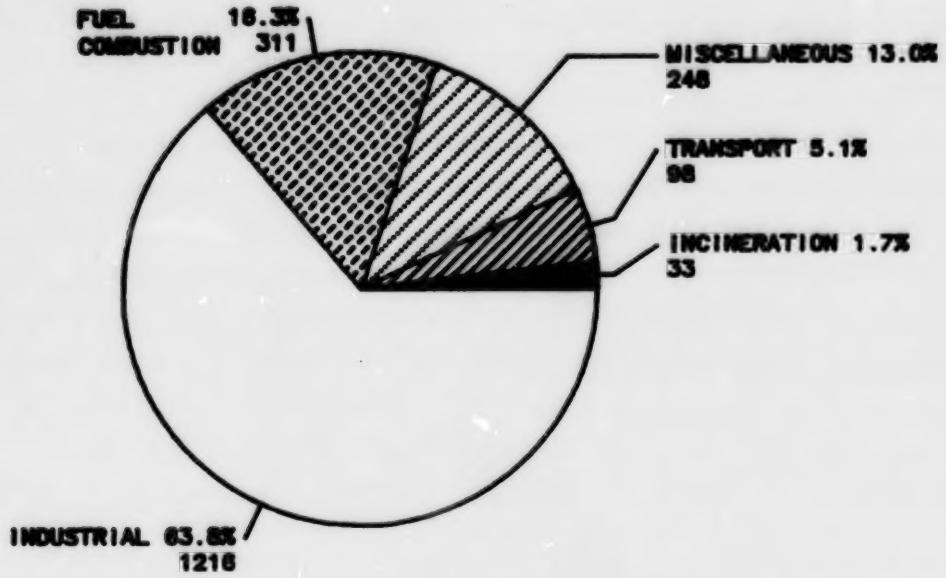


FIGURE 1 DISTRIBUTION OF NATIONAL PARTICULATE EMISSIONS FOR 1980 (kilotonnes)

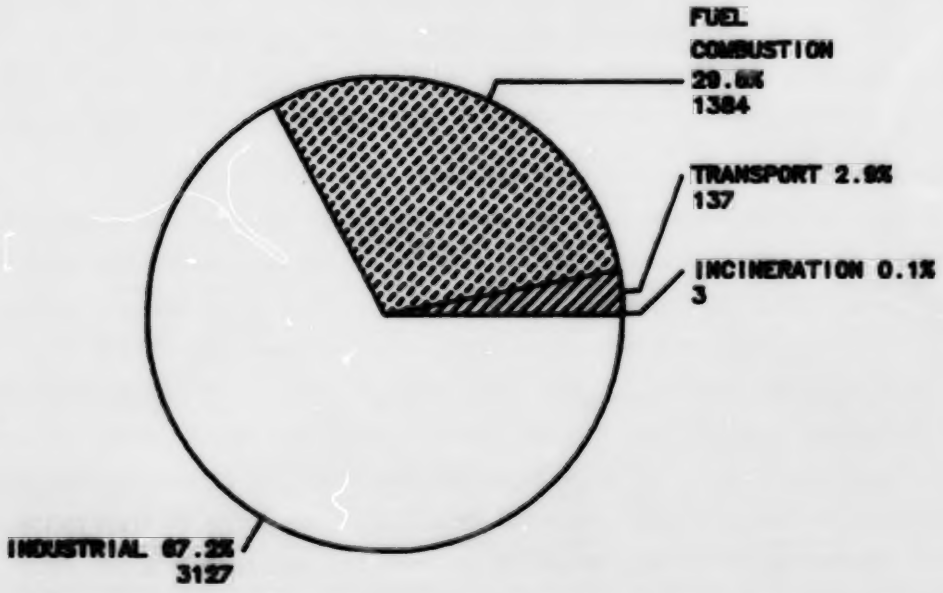


FIGURE 2 DISTRIBUTION OF NATIONAL SULPHUR DIOXIDE EMISSIONS FOR 1980 (kilotonnes)

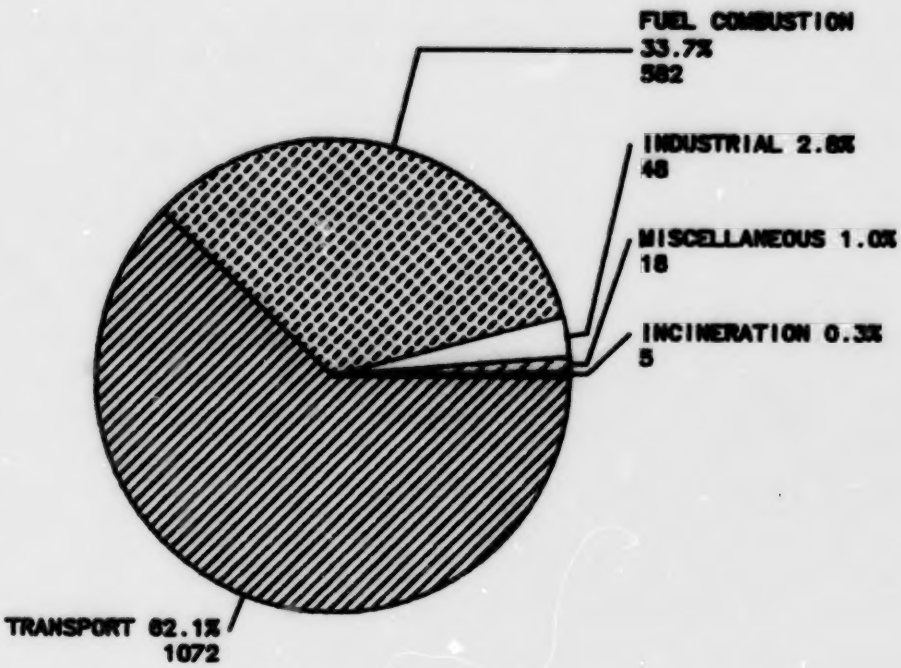


FIGURE 3 DISTRIBUTION OF NATIONAL NITROGEN OXIDES EMISSIONS FOR 1980 (kilotonnes)

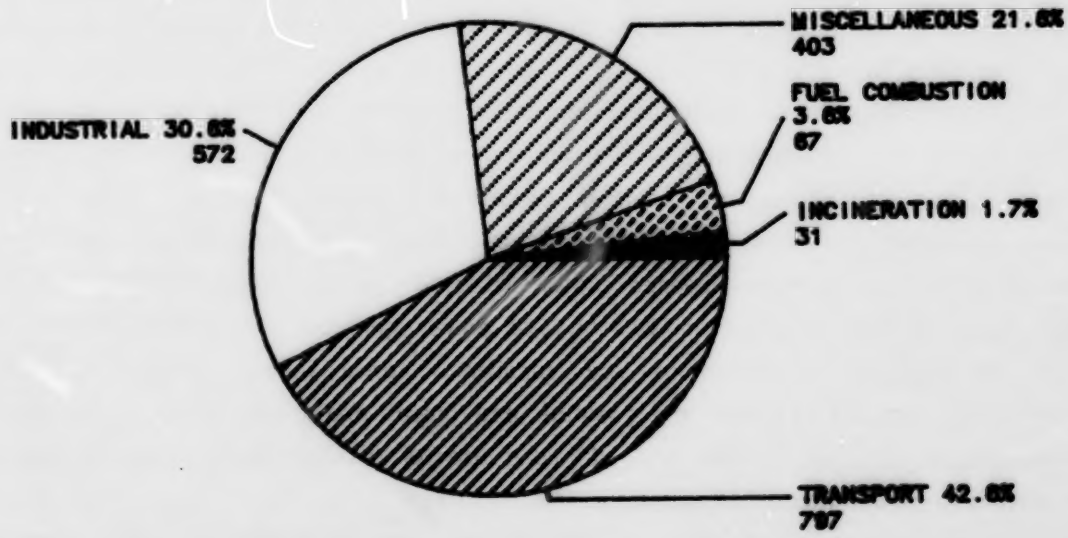


FIGURE 4 DISTRIBUTION OF NATIONAL HYDROCARBON EMISSIONS FOR 1980 (kilotonnes)

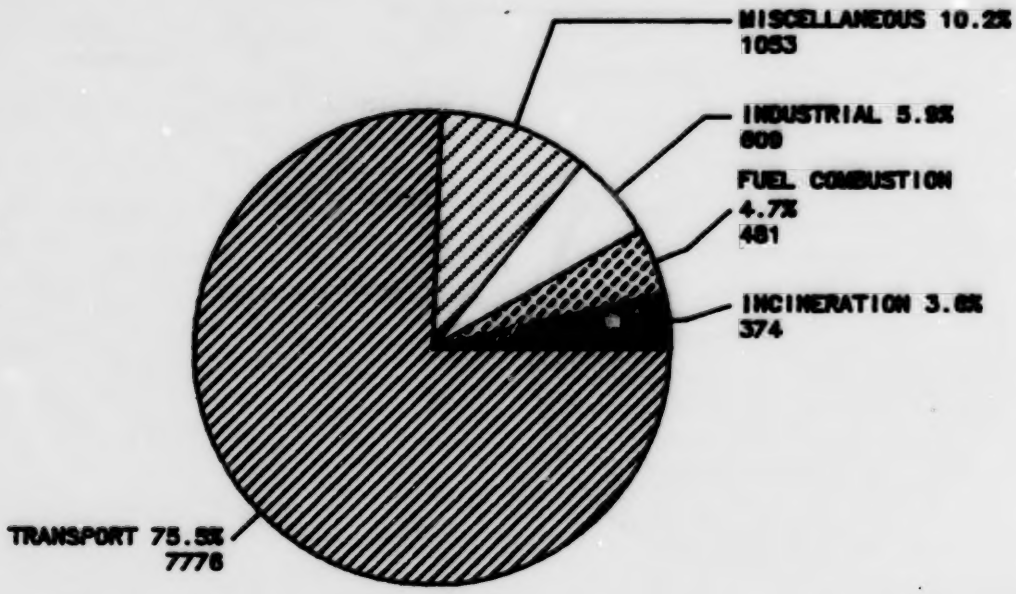


FIGURE 5 DISTRIBUTION OF NATIONAL CARBON MONOXIDE EMISSIONS FOR 1980 (kilotonnes)

A detailed breakdown of emissions of the five contaminants on a source-by-source basis is given in Table 2. A provincial breakdown of the emissions by source is given in Appendix A.

Nationally, major particulate sources are mining and rock quarrying (10.7%), iron ore mining and beneficiation (8.3%), and power generation (7.7%). Sulphur oxide emissions come primarily from primary copper and nickel smelting (41%), power generation (16.5%), and industrial fuel combustion (9.9%). Major contributors to nitrogen oxide emissions are gasoline-powered motor vehicles (26.1%); diesel-powered engines (24%); industrial fuel combustion (15.5%); and power generation (13.3%). Important sources of hydrocarbon emissions are gasoline-powered motor vehicles (32.9%); petrochemical industry (11.3%); and gasoline and diesel marketing (7.7%). Gasoline-powered motor vehicles (62.8%) and off road use of gasoline (8.6%) are the major contributors to carbon monoxide emissions.

The emissions of all five contaminants are controlled to some extent. Particulate matter from fuel combustion and industrial processes are generally well controlled. The four gaseous contaminants are controlled to a lesser extent although

TABLE 2 NATIONWIDE EMISSIONS OF AIR CONTAMINANTS, BY SOURCE (1980)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Industrial Processes					
Iron Ore Mining and Beneficiation	158 548	160 713	-	-	34 056
Pyrrhotite Roasting	603	69 602	-	-	-
Iron and Steel Production	77 071	10 909	-	-	63 695
Primary Aluminum Production	41 167	45 781	9 858	1 470	134 615
Primary Copper and Nickel Production	50 777	1 898 273	-	-	-
Copper and Nickel Refining	3 263	1 349	-	-	-
Primary Lead and Zinc Production	11 705	119 037	-	-	-
Gold Production	208	15 144	-	-	-
Ferroalloy Manufacture	16 984	4 412	-	-	16 762
Abrasives Manufacture	8 325	7 775	-	-	6 324
Ferrous Foundries	8 252	-	-	-	5 200
Magnesium Production	309	-	-	-	-
Asbestos Production	49 103	-	-	-	-
Mining and Rock Quarrying	203 820	681	-	-	-
Salt Production	7 924	-	-	-	-
Lime Manufacturing	24 897	-	-	-	-
Gypsum Processing	22 904	-	-	-	-
Nepheline Syenite Processing	459	-	-	-	-
Sodium Carbonate Production	960	-	-	-	-
Potash Processing	15 007	-	-	-	-
Silica Processing	2 489	-	-	-	-
Stone Processing	31 817	-	-	-	-

TABLE 2 NATIONWIDE EMISSIONS OF AIR CONTAMINANTS, BY SOURCE (1980) (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Sand and Gravel Processing	10 204	-	-	-	-
Cement Manufacture	11 771	-	-	-	-
Contrete Batching	2 196	-	-	-	-
Asphalt Production	33 094	-	-	-	-
Glass Manufacturing	1 410	-	-	-	-
Pigments Production	147	2 905	-	-	-
Ammonium Sulphate	93	-	-	-	-
Clay Products Manufacture	11 514	-	-	-	-
Crude Oil Production	-	32 850	-	28 172	-
Petroleum Refining	8 887	78 061	5 622	133 695	173 572
Natural Gas Processing	-	383 961	-	5 847	-
Tar Sands Operations	22 602	149 600	9 620	18	287
Coal Industry	103 336	-	-	153 806	-
Metallurgical Coke Manufacture	22 969	9 897	76	1 821	1 751
Petrochemical Industry	-	-	-	211 297	-
Plastics Fabrication	-	-	-	19 376	-
Carbon Black	15	1 671	-	58	112 012
Sulphuric Acid Production	-	15 892	-	-	-
Nitric Acid Production	-	-	6 883	-	-
Phosphoric Acid Production	371	-	-	-	-
Phosphate Rock Processing	8 423	-	-	-	-
Phosphate Fertilizer Manufacture	3 961	-	-	-	-
Elemental Phosphorus Production	9 866	2 934	-	-	-
Nitrate Fertilizer Manufacture	6 430	-	172	-	-

TABLE 2 NATIONWIDE EMISSIONS OF AIR CONTAMINANTS, BY SOURCE (1980) (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Grain Handling and Milling	63 602	-	-	-	-
Bakeries	-	-	-	3 660	-
Sulphate (Kraft) Pulping	106 905	29 837	15 895	12 298	60 360
Sulphite Pulping	1 110	85 486	-	-	-
Sawmills	55 233	-	-	-	-
Pulpboard Manufacture	1 446	-	-	116	-
Plywood and Veneer	6 376	-	-	226	-
SUBTOTAL	1 215 741	3 126 770	48 126	571 860	608 634
Fuel Combustion/ Stationary Sources					
Power Generation by Utilities	147 676	767 727	228 802	5 833	20 228
Residential Fuel Combustion	5 889	67 492	44 816	6 170	20 018
Industrial Fuel Combustion	61 090	459 883	266 964	49 291	38 723
Commercial Fuel Combustion	8 254	85 994	36 335	2 523	9 623
Fuel Wood Combustion	87 969	2 531	5 250	3 318	392 692
SUBTOTAL	310 878	1 383 627	582 167	67 135	481 284
Transportation					
Gasoline-powered Motor Vehicles	45 072	19 854	450 797	616 241	6 458 352
Railroads	7 293	3 686	107 183	26 798	38 977
Marine	6 001	65 685	31 192	40 183	100 139
Aircraft	1 581	2 480	41 726	19 858	165 163
Off-road Use of Gasoline	1 653	1 244	26 621	47 177	887 722
Diesel-powered Engines	33 382	43 353	414 306	46 272	125 727

TABLE 2 NATIONWIDE EMISSIONS OF AIR CONTAMINANTS, BY SOURCE (1980) (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Tire Wear	3 423	-	-	687	-
SUBTOTAL	98 405	136 202	1 071 825	797 216	7 776 080
Solid Waste Incineration					
Municipal Incineration	1 994	1 180	1 268	639	15 557
Industrial and Commercial Incineration	961	576	627	192	691
Sewage Sludge Incineration	291	983	301	76	-
Wigwam Burners	30 255	274	2 750	30 255	357 538
SUBTOTAL	33 501	3 013	4 946	31 162	373 786
Miscellaneous					
Fertilizer Application	7 127	-	-	-	-
Pesticide Manufacturing and Application	26 715	-	-	-	-
Gasoline and Diesel Marketing	-	-	-	143 656	-
Dry Cleaning	-	-	-	16 602	-
Application of Surface Coatings	-	-	-	141 641	-
Structural Fires	5 058	-	-	5 058	10 115
Cigarette Smoking	4 849	-	-	-	1 940
General Solvent Use	-	-	-	76 681	-
Slash Burning	204 390	-	18 178	19 653	1 040 620
SUBTOTAL	248 139	-	18 178	403 291	1 052 675
TOTAL	1 906 664	4 650 262	1 725 242	1 870 664	10 292 459

* Expressed as SO_2
** Expressed as NO_2

advances have been made to reduce the quantities generated at the process or fuel combustion stage instead of focussing on subsequent control measures. The emissions shown in this document reflect final release to the atmosphere; any control measures have been considered.

Emissions resulting from the combustion of coal, natural gas, light oil, and heavy oil are included in Appendix D. These emissions are generated from residential heating, commercial and industrial units and power generating stations. The emissions from these fuels do not add up to those from the stationary fuel combustion category since emissions from the combustion of other types of fuels are also included in the overall category.

The emissions data have also been resolved to a 127 x 127 km national grid. The five geographical maps of Canada indicate the emission densities by grid for each contaminant. Major sources of emissions are computed on specific geographical points while emissions from area type sources are distributed to each grid based on various allocation parameters such as population and agricultural land area. Major sources are generally defined as those that emit over 100 t/yr of a common contaminant.

Emissions of all contaminants are highest around major population centres but are also shown in northern Canada or in unpopulated areas resulting from the distribution of emissions from sources such as slash burning and aircraft flight routes.

2 BASIC METHODOLOGY AND DATA SOURCES

The 1980 inventory of emissions was compiled using the bottom-up approach, that is, emissions were computed at the industrial process level, by type of fuel or product, and by individual industrial sites for major emission sources. The computations were made using the National Emission Inventory System (NEIS), a computerized database management system which facilitated the roll-up of data to standard industrial classification codes and to the provincial and national level. Minor point specific emission sources and area emission sources were compiled for standard industrial classification codes at the provincial level.

Sources of data required for compiling such an inventory are very numerous. A brief description follows that indicates the procedures and data sources used to compute the emissions for the year 1980. In an effort to present the sources of data in a condensed and concise form, the industrial sectors that were examined using similar methodologies have been grouped into sub-categories.

2.1 Industrial Processes

2.1.1 Non-ferrous Smelters. This sub-category applies to:

- aluminum production;
- lead/zinc production;
- copper/nickel production; and
- pyrrhotite roasting.

Non-ferrous smelters are the major sources of SO_2 emissions in Canada. For aluminum smelters in Quebec, company estimates of SO_2 emission rates were taken from the 1980 federal/provincial emissions inventory study (1). For other major smelters, SO_2 emissions were provided by provincial agencies or regional offices of Environment Canada (1,2,3). Emissions data for other contaminants were not available from provincial agencies or the industry; therefore, the emissions were calculated using 1978 emission factors which were developed from questionnaire data (5), internal studies (5,11,12,19), and production data obtained from other federal departments (1,4,6,7,8,9,10,13).

2.1.2 Ferrous Industries. This sub-category concerns:

- iron ore mining and beneficiation;
- ferrous foundries;
- iron and steel production; and
- ferro-alloys production.

Energy, Mines and Resources (EMR) supplied the greatest scope of information on plant productions, capacities and processes for all sectors of the ferrous industry (14,15,16,17).

Emissions from iron ore mining and beneficiation were calculated using emission factors developed from plant response questionnaires; from information provided by the Industrial Programs Branch of Environment Canada (5); and from consultations (18). Sulphur dioxide emissions for sintering operations at Algoma were obtained from the Ontario Ministry of the Environment (2).

Emissions from iron and steel production were based on emission factors developed from questionnaires (5); from emissions data taken from the 1980 federal/provincial emissions inventory study (1); and from other internal inventory studies done for specific regions of the country (12,19).

For ferrous foundries, emissions were determined using 1974 emission factors and information on plant modifications obtained through discussions with the Industrial Programs Branch staff of Environment Canada (18). Production statistics were also obtained from Statistics Canada publications (20,21).

Ferro-alloys were mainly produced in the province of Quebec and one facility located in Ontario. Emissions from Quebec plants were taken from the 1980 federal/provincial emissions inventory study (1) for all processes except material handling operations which were calculated using an Environment Canada emission factor (5).

2.1.3 **Mining and Mineral Processing.** This sub-category applies to:

- mining and rock quarrying;
- sand and gravel processing;
- asbestos production;
- lime manufacturing;
- potash processing;
- stone processing;
- salt production;
- silica processing;
- gypsum processing; and
- nepheline syenite processing.

Information pertaining to production was obtained primarily from the Canadian Mineral Yearbook preprints (23 to 30) published by Energy, Mines and Resources (EMR) for all sectors with the exception of mining and rock quarrying, asbestos and potash. Production of potash from most plants was taken from a Northwest Region study on emissions (19), while the Canadian Mineral Yearbook (32) preprint was used to estimate production for one plant. Asbestos production for the province of Quebec was taken from the 1980 federal/provincial emissions inventory study (1), and the production for the other provinces was estimated using the Canadian Mineral Yearbook preprint. For Mining and Rock Quarrying, Statistics Canada supplied the required information on production quantities (33,34,35).

Emissions from the sectors in this sub-category were mainly calculated using emission factors taken from a U.S. Environmental Protection Agency (EPA) publication (36), except for potash processing, asbestos production, and mining and rock quarrying. Emissions from potash processing were determined using stack test results supplied in the regional study (19) for all but two plants. In these two cases, emissions were calculated using emission factors provided by the EPS regional office (3). Emissions from asbestos production were estimated using emission factors from a published EPS report on the industry (37). For the mining and rock quarrying sector, emissions were approximated using emission factors developed from questionnaire data for drying facilities (5), and from a U.S. EPA publication for mining and quarrying operations (36).

2.1.4 Wood and Paper Industry. This sub-category concerns:

- sulphite pulping;
- sawmills;
- pulpboard manufacture;
- sulphate (Kraft) pulping; and
- plywood and veneer manufacture.

Emissions were computed on a provincial basis except for pulping plants, because of the large number of wood and wood products manufacturing plants. For the numerous small establishments, production values on a provincial basis were obtained as shipments of lumber and wood products from Statistics Canada (31,38,39). Statistics not given for certain provinces were calculated using capacity and production figures from Industry, Trade and Commerce (40) and the Forest Products Directory (41). Emissions were calculated using emission factors from a U.S. Environmental Protection Agency publication (36).

Plant production data for sulphite and sulphate pulping mills were obtained from information submitted to Environment Canada by the companies as part of their compliance with clean water practices regulations (11) and from the 1980 federal/provincial emissions inventory study for Quebec (1). Emissions were generally calculated using emission factors taken from a published EPS report on the industry (42). For the western provinces and Quebec, emissions were based on a combination of EPS developed emission factors (42) and survey based data reported in other studies (1,19).

2.1.5 Fossil Fuels Production. This sub-category applies to:

- crude oil production;
- natural gas processing;
- coal industry;
- petroleum refining;
- tar sands operations; and
- metallurgical coke.

The amount of crude oil produced and imported was obtained from Statistics Canada (44,45,46). Emission estimates for crude oil production consider three major sources; production of crude oil, marine handling, and transfer operations. Emissions of sulphur dioxide from sour oil batteries in Alberta were provided by Environment Canada's regional office (3). Hydrocarbon emissions were calculated using emission factors from a U.S. EPA publication (43) and an Environment Canada study (19) for crude production and handling, respectively.

Production or crude throughput figures for petroleum refineries were obtained from an Oilweek publication (47); from Statistics Canada (44); and from the 1980 federal/provincial emissions inventory study (1). Crude throughput and emission factors were used to calculate hydrocarbon emissions from storage tanks and miscellaneous sources. For storage tank emissions, emission factors were calculated from the 1978 PACE data (48) while emission factors from a U.S. EPA publication (36) were used for miscellaneous emissions. Emissions from fuel combustion were calculated using emission factors from a U.S. EPA publication (36) for all pollutants except for SO_2 where refinery fuel consumption statistics and sulphur contents were obtained from company data supplied to Environment Canada (49). Process sulphur dioxide emissions were provided by the provinces (3). Other emissions within refineries were obtained through the provinces (3), or estimated from 1978 PACE data (48) or other studies (1,12,19).

Information on natural gas processing in Alberta, including raw gas receipts, marketable gas produced, fuel gas consumed, gas flared, and sulphur dioxide emissions from plants with sulphur recovery, were obtained from Energy Resources Conservation Board (ERCB) on a plant by plant basis (50,51). Additional information on sulphur dioxide emissions for natural gas processing were obtained from Alberta Environment (52) while fuel combustion emissions were calculated using emission factors from a U.S. EPA publication (36). Emissions for natural gas plants in British Columbia and Saskatchewan were taken from other studies (12,19). For Ontario, emissions from the natural gas industry were estimated using information from Statistics Canada (44) and Environment Canada's internal documentation (49).

For the tar sands operations, emission data were taken from an internal survey study (19) and Alberta Environment through Environment Canada's regional office (3,52).

Three sources of emissions were investigated for the coal industry: coal cleaning plants, mining, and transportation. Information on emissions for coal cleaning plants was taken from internal survey studies (12,19). Mining emissions were calculated

using the quantity of coal mined, obtained from a Canadian Mineral Yearbook preprint (53) and emission factors taken from a U.S. EPA publication (36). Information on fugitive emissions from transportation and hydrocarbon emissions from mining were obtained from internal sources (49,54).

Statistics on the production of metallurgical coke were obtained from a Canadian Mineral Yearbook preprint (53). Emissions were calculated using the production statistics and emission factors from internal survey studies (12,19) and an Environment Canada report (55) on the industry.

2.1.6 Chemical Industry. This sub-category applies to the following sectors:

- phosphoric acid;
- nitric acid;
- phosphate fertilizers;
- phosphate rock processing;
- petrochemicals;
- sulphuric acid;
- nitrate fertilizers;
- elemental phosphorus;
- ammonium sulphate; and
- carbon black.

Plant capacities and production data for the these sectors except for sulphuric acid manufacturing were obtained from published survey data (56). Only the sulphuric acid plants burning sulphur to make acid were considered since acid made from smelter off gases was considered as by-product from sulphur dioxide control. The amount of sulphur burned to produce acid was obtained from EMR (57).

For carbon black, sulphuric acid, and nitric acid production, emissions were calculated using the plant production data and average emission factors taken from an internal survey (58). Emission factors from a U.S. EPA publication (36) were used to estimate the emissions from phosphate rock and nitrate fertilizer industries. Emissions resulting from phosphoric acid production were taken from the 1980 federal/provincial emissions inventory study (1), while those from elemental phosphorus production were obtained either from this same study or from Environment Canada's internal information (58). Emissions from the manufacturing of phosphate fertilizers were calculated using plant production data and emission factors taken from a U.S. EPA publication (36). Emissions from petrochemical plants were determined using emission factors from a U.S. EPA study (59) and from information supplied by Environment Canada (58).

2.1.7 Other Manufacturing Industries. The following sectors are included in this sub-category:

- abrasives industry;
- concrete batching;
- glass manufacturing;
- clay products;
- cement production;
- asphalt production;
- pigments production;
- bakeries; and

- grain handling and milling;
- plastics fabrication;
- magnesium production.

Information required to estimate plant productions for emission calculations for most of these manufacturing sectors except for cement production, magnesium, and pigments production was obtained from Statistics Canada publications (22,60 to 68). Cement production by plant was estimated using plant capacity and production data from EMR (18); Environment Canada's internal survey study (19); and the 1980 federal/provincial emissions inventory study (1). Information for magnesium was obtained from EMR (69), while information on the production of titanium dioxide pigments was available from CPI products profiles (56).

Having the production statistics, emissions were calculated by the emission factor approach. Plastics fabrication and bakeries emission factors were taken from an internal survey study on emissions of volatile organic compounds (70). Abrasives manufacturing emission factors were obtained internally (5). Concrete batching and clay products emission factors obtained from a U.S. EPA publication (36) were used with control efficiencies developed internally (11). Emissions data for the cement industry were obtained from an internal survey study (19), an Environment Canada report of the industry (5), and from the federal/provincial emissions inventory study (1). Emission factors for magnesium production were developed from internal survey data (11) and from a U.S. EPA report (71). Information from Environmental Protection Agency studies (72,73) was also used for the glass manufacturing and grain handling sectors. Asphalt production emission factors were developed based on a plant survey in Nova Scotia (3), and titanium dioxide emissions data were taken from the 1980 federal/provincial emissions inventory study (1).

2.2 Fuel Combustion/Stationary Sources

This category includes:

- electric power generation;
- residential fuel combustion;
- commercial fuel combustion;
- industrial fuel combustion; and
- fuel wood.

Fuel consumption statistics required for estimating provincial atmospheric emissions for electrical power utilities were obtained through the regional offices (3,76), an internal survey study (74), and Statistics Canada (67). Emissions data for utilities in Eastern Canada were also provided by the provinces. Those for western Canadian utilities were obtained either from provincial data (3) or from internal survey studies (12,19).

Emissions for smaller stations were calculated on a provincial basis using EPA emission factors (36) and Statistics Canada fuel consumption information (67).

Fuel consumption data for residential, commercial and industrial applications were taken from Statistics Canada (67). Emissions were then calculated using updated emission factors from a U.S. EPA publication (36). Average sulphur contents of fuels were considered for each region in Canada from information submitted to Environment Canada (49) by the petroleum refineries. Emissions from fuel wood combustion were calculated using emission factors taken from an Environment Canada study (75).

2.3 Transportation

This category includes:

- gasoline-powered motor vehicles;
- railroads;
- marine;
- aircraft;
- off-road use of gasoline;
- diesel-powered engines; and
- tire wear.

Gasoline-powered vehicles were grouped into six categories; automobiles, light-duty trucks, heavy-duty trucks, motorcycles, and snowmobiles. Provincial vehicle registrations were taken from Statistics Canada (77). Registrations by truck size were estimated using total truck registrations and a vehicle percent distribution determined by Environment Canada (54). Emissions were then calculated using the vehicle registrations, emission factors, and vehicle distance travelled statistics which were estimated internally (54). For estimating motorcycle and snowmobile emissions, emission factors from a U.S. EPA publication (36) were used. Emission factors were based on Canadian conditions and were computed using a computerized system known as Mobile 2 developed by the U.S. EPA. The system takes into account several variables that affect the overall emission rates.

For the railroads sector, emissions resulting from the combustion of diesel fuel oil were calculated using fuel consumption data from Statistics Canada (67) and EPA emission factors (36).

Three categories of emissions for the marine sector were considered: emissions from ships in port running auxiliary generators; emissions from inland water travel by steam and motor ships; and emissions from pleasure craft. Emissions from auxiliary generators were calculated based on the number of calls in port by ships obtained from Statistics Canada publications (78,79). Emission factors were obtained from a U.S. EPA publication (36) and an average layover in port of 1.66 days obtained from a survey of Harbour Masters (80) was used. Inland water travel by ships was

considered only for the Great Lakes, St. Lawrence Seaway system. Underway emissions were calculated based on marine fuel sales of diesel and residual oil obtained from Statistics Canada (67), provincial sulphur contents (49) and EPA emission factors (36). Emissions from outboard motor boats were calculated using the number of power boats taken from a Statistics Canada publication (81); and emission factors from a U.S. EPA publication (36). An average horsepower of 9.1 and an operating time of 50 h/yr were estimated internally (54).

Aircraft emissions were computed by considering both landing and takeoff cycles as well as inflight emissions. Landing and takeoff emissions were developed from statistics on taxiing, takeoff, climbout, and landing operations with emissions centralized at or around the airport. These emissions were calculated based on aircraft movement by type of aircraft obtained from Transport Canada (82,83) and emission factors for the landing-takeoff cycle taken from a U.S. EPA publication (36). Inflight emissions occur at substantial altitudes and were apportioned geographically based on major flight paths. Emissions were calculated based on hours flown by type of aircraft provided by Transport Canada (82,84) and emission factors by type of engine taken from a U.S. EPA publication (36). Emissions were also estimated for auxiliary power units but emissions were deemed negligible by comparison and were not included in the total.

The off-road use of gasoline accounts for emissions associated primarily with agricultural use but also includes all emissions resulting from gasoline consumption which is not sold at retail pumps. Emissions were calculated using the difference between gross and net sales of gasoline taken from Statistics Canada (67,85) and applying emission factors taken from a U.S. EPA publication (36).

Diesel-powered vehicles sector includes emissions from heavy-duty diesel trucks, and various off-road diesel uses. Emissions from diesel trucks were calculated in the same manner as for gasoline-powered vehicles, the percentage of diesel trucks to the total truck fleet and the required emission factors were determined internally (54). Other diesel consumption by industry was available from Statistics Canada (67) and the emissions were calculated using emission factors from a U.S. EPA publication (36).

Emissions from tire wear were approximated using total vehicle miles travelled. This estimate was calculated using vehicle registrations from Statistics Canada (77) and the kilometres travelled by type of vehicle estimated internally (54). Emission factors were calculated based on an average tire life of 22 000 km and an estimated 1.08 kg of rubber lost per tire (86,87). An average of four tires per vehicle and eight tires for heavy duty vehicles were assumed. A General Motors' study which indicated that 5%

of total tread wear is in the form of airborne particulates and 1% in the form of hydrocarbon gases was used to develop the emission factors (88).

2.4 Solid Waste Incineration

This category includes:

- municipal incineration;
- industrial and Commercial incineration;
- sewage sludge incineration; and
- wigwam burners.

Waste throughputs for municipal and sewage sludge incinerators were obtained from the provinces (3,19), however, emissions data were available for only three incinerators. Emissions for the remaining incinerators were therefore calculated using the throughput statistics and EPA emission factors (36) or from internal studies (11,89,90).

Information was not available on the throughput of industrial and commercial incinerators hence an EPA developed ratio of 16.6t of municipal waste to 9t of industrial/commercial waste was utilized (4). Emissions were estimated using emission factors taken from an EPS report on packaged incinerators (90) and assuming that 75% of wastes were burned in multiple-chamber type incinerators and the remainder in controlled air type incinerators.

Information on the amount of wood waste burned in wigwam burners was also limited. A conversion factor developed internally was therefore applied to the total lumber production as reported by Statistics Canada (91). Emission factors from an internal study were used to compute the emissions (92).

2.5 Miscellaneous

This category includes:

- fertilizer application;
- pesticide manufacturing and application;
- gasoline and diesel marketing;
- dry cleaning;
- application of surface coatings;
- structural fires;
- cigarette smoking;
- general solvent use; and
- slash burning.

Information from Statistics Canada was used to determine the level of activity for calculating the emissions for five of these factors. Gasoline and diesel fuel marketing emissions were computed using net fuel sales (67) and EPA emission factors (36). Surface coating emissions were estimated using the quantity of solvents used by the paint and varnish manufacturers (93). Emissions were assumed to be 100% of solvents consumed for residential use while 10 000 t of solvents were assumed to be recovered by controls in

industrial and commercial installations (11,58). For cigarette smoking, the total quantity of tobacco products sold (94) in conjunction with emission factors taken from a U.S. study (95) were used to calculate the emissions. The quantity of slash burned was calculated by applying a ratio factor developed internally (49) to the total primary forest production (91). EPA emission factors (36) and another U.S. study (96) on prescribed fires were used to estimate the emissions. For general solvents use, emissions were developed from an internal study (70). Emissions from structural fires were calculated using statistical data on the number of structural fires (97) and emission factors taken from a U.S. EPA publication (36). Emissions resulting from fertilizer application were estimated using fertilizer sales obtained from the Canadian Fertilizer Institute (98) and an emission factor from a U.S. EPA report (99) on phosphorus. Dry cleaning emissions were estimated based on the quantity of solvents used and on the expected solvent losses indicated in an internal study (56,58).

3 EMISSION TRENDS

Emission trends information is important, because it leads to a better understanding of relationships between the releases of pollutants to the atmosphere and their potential to harm the environment, and is an indispensible tool in the assessment of control options. This section summarizes the results of a retrospective study on the emissions of the five common contaminants, (sulphur dioxide, nitrogen oxides, carbon monoxide, hydrocarbons and particulate matter) from anthropogenic sources for the years 1970 to 1980. This study evolved from the project that began with the preparation of the 1955 and 1965 emission estimates in response to requirements for the Canada/U.S. Memorandum of Intent Work Group 3B Report.

The information presented here can, on request, be tabulated in greater detail; from a national sectorial level to a provincial sectorial level (see Appendix B for provincial emissions, Figures B1-B12). In many ways this compilation, covering the past decade, presents more industrial and other anthropogenic sectors than previous inventories up to 1976. Since the same number of sectors are used in each year with a consistent methodology for each sector, this inventory provides a good basis for comparing the spatial and temporal changes of emissions in the provinces and territories of Canada and their potential impact on the environment.

The make-up of the database in terms of the number of industrial category sectors considered was based mainly on the availability of reliable and consistent information for 1970 through 1980. Table 3 is a listing of all the sectors covered in the emission trends data base. It contains most of the sectors which account for over 95% of the total 1980 emissions. There are minor differences between the 1980 inventory and the 1980 emission trends inventory that arise from the omission of less significant sectors mainly in the miscellaneous category for which no consistent information source was available. Also excluded from this report are forest fires because this source is not exclusively anthropogenic in nature and moreover the emissions are highly variable from year to year which would tend to hide any apparent trends.

3.1 General Methodology

The emission trends inventory was compiled on a sector basis using standard industrial classification codes and by province. The emission estimates were then aggregated to give total provincial and national emission estimates. For most sectors the calculation procedure can generally be expressed as:

$$\text{Emission} = \text{Activity Level} \times \text{Emission Factor}$$

TABLE 3 LIST OF SECTORS IN EMISSION TREND ANALYSIS

Industrial Processes

Non-ferrous Smelters

- Copper/Nickel Production
- Pyrrhotite Roasting
- Aluminum Production
- Lead/Zinc Production

Ferrous Industries

- Iron Ore Mining and Beneficiation
- Iron and Steel Production
- Ferro-alloys Manufacture

Mining and Mineral Processing

- Mining and Rock Quarrying
- Sand and Gravel Processing
- Asbestos Production
- Lime Manufacturing
- Potash Processing
- Stone Processing
- Salt Production
- Gypsum Processing
- Silica Processing

Fossil Fuels Production

- Petroleum Refining
- Tar Sands Operations
- Metallurgical Coke Manufacture
- Crude Oil Production
- Natural Gas Processing
- Coal Industry

Wood and Paper Industry

- Sulphite Pulping
- Sulphate (Kraft) Pulping

Chemical Industry

- Phosphoric Acid Production
- Nitric Acid Production
- Super Phosphate Production
- Phosphate Rock Processing
- Petrochemical Industry
- Sulphuric Acid Production
- Elemental Phosphorus
- Ammonium Nitrate
- Carbon Black
- Urea Production

Other Manufacturing Industries

- Cement Manufacture
- Asphalt Production
- Abrasives Manufacture
- Concrete Batching
- Glass Manufacture
- Grain Handling and Milling
- Plastics Fabrication

Fuel Combustion/Stationary Sources

- Electric Power Generation
- Residential Fuel Combustion
- Commercial Fuel Combustion
- Industrial Fuel Combustion

Transportation

- Gasoline-powered motor vehicles
- Railroads
- Marine
- Aircraft
- Off-road Use of Gasoline
- Diesel-powered Engines

Solid Waste Incineration

- Industrial and Commercial Incineration
- Wigwam Burners

Miscellaneous

- Application of Surface Coatings
- Gasoline and Diesel Marketing
- Dry Cleaning
- Slash Burning
- General Solvent Use

In order to provide a common basis for comparison, which is essential to the evaluation of emission trends from 1970 to 1980, it was necessary that each sector be treated consistently with respect to the sources of statistical data on production, fuel consumption, etc., and in the use of the most current uncontrolled emission factors as well as the degree of emission control utilized in each sector for each year.

The emission factor approach is the preferred method for developing retrospective emission estimates. However, for some sectors such as nonferrous smelters and thermal power generation where the emissions data were provided by industry for the entire period from 1970 to 1980, those data were judged to be more representative and were used in this report.

The definitions of the sectors and source categories used here are essentially the same as those used in the 1980 emissions inventory. This consistency in definitions also applies to specific sources of national statistics for the production, consumption and distribution of goods and services as well as to the derivation of emission factors.

Most of the industrial production and fuel consumption data were derived from national statistics compiled and maintained by Statistics Canada and EMR. One type of EMR publication that was used extensively in the emission trends study was the Canada Minerals Yearbook. Statistics Canada reports provided information on production (commodities), distribution of goods, including transportation and demographics. Other valuable sources of information came from provincial governments as well as industry association reports.

The uncontrolled emission factors came mainly from a U.S. EPA publication AP-42 and are current up to Supplement 14. These emission factors were modified by emission control information as determined from industry surveys carried out by Environment Canada. Average sulphur and ash contents of coal were derived from EMR surveys and sulphur contents of liquid fuels were supplied to Environment Canada by fuel producers as a regulatory requirement.

The following articles will outline departures from the general methodology either in basic approach as regards to the calculation of emissions or in the main source of basic information relating to production data or derivation of emission factors.

3.1.1 Industrial Processes. In the non-ferrous smelter sectors specifically for primary copper and nickel SO_2 emissions were provided by industry to Environment Canada for use in the preparation of a report, "Copper-Nickel Smelting Complexes in Canada: SO_2 Emissions (1950-2000)". Due to the changes in the smelting processes over

the time period 1970 to 1980, the information provided by industry formed the only basis for a reasonable estimate of sulphur dioxide emissions.

3.1.2 Fossil Fuels. The amounts of crude oil processed were obtained by supplementing Statistics Canada information with that from the Oilweek journal. The Petroleum Association for Conservation of the Canadian Environment (PACE) report No. 85 was used in the development of emission factors for the petroleum refining sector.

In natural gas production, the amount of gas processed as well as sulphur dioxide emitted was obtained from Energy Resources Conservation Board (ERCB) publications and Alberta Environment reports. Alberta Environment reports were also used to estimate emissions from tar sands.

3.1.3 Chemical Industry. For the Chemical Industry subcategory the amounts of chemical products produced were obtained from Corpus Information Services Limited, CPI Product Profiles.

3.1.4 Fuel Combustion/Stationary Sources. For electric power generation fuel consumption statistics as well as emissions of particulate, sulphur dioxide and nitrogen oxides were obtained from reports published by Ontario Hydro, Alberta Environment, ERCB (Alberta), New Brunswick Power Commission, Nova Scotia Power Corporation.

3.1.5 Transportation. The emissions from transportation sources were determined in three ways: vehicle registration, fuel consumption and use statistics such as take-off and landing cycles or calls at port. Vehicle registrations were used to estimate the emissions from automobiles and trucks (road vehicles); the emission factors were developed using software based on EPA's Mobile 2.

3.2 Discussion

The early 1970s were the starting point for a number of important economic changes that will continue to affect air pollution emissions far beyond today. Because of growing public awareness about environmental issues, legislation such as the "Clean Air Act" and the "Motor Vehicle Safety Act" were introduced. Industries were encouraged to adopt pollution abatement technologies into their processes to limit the releases of such pollutants as sulphur dioxide and particulate matter. The releases of automobile pollutants were regulated and systems such as catalytic converters and EGR (exhaust gas recirculation) valves were built into new automobiles.

The early seventies were a time of economic crisis created by a sudden rise in energy (oil) prices. There was a significant change in the world economic structure at this

time due to a general recession. The demand for Canadian products, especially in the heavy industry sectors, declined. The higher prices for oil and oil products made alternate energy sources as well as fuel conservation practices (including insulation) more economical and in many cases necessary. The high price of oil (gasoline) created a bigger market for smaller fuel efficient automobiles, and influenced the change of fuel use patterns in stationary fuel combustion away from oil to electricity, natural gas and wood.

As the economy recovered from the 1974-75 recession, emissions from industrial and other economic sectors increased; however, these increases were greatly moderated by: the emission control equipment installed in different plants; the closure of the older, less efficient processes and facilities; the emission controls on automobiles; and the greater use of cleaner fuels. During this period, Canada registered some dramatic improvements in air quality (123).

3.2.1 Particulate. Particulate matter emissions generally come from industrial sources, stationary fuel combustion, and miscellaneous sectors. The overall decline in particulate emissions has been 8% (Table 4) and the industrial share of total particulate matter emissions declined from 70% in 1970 to 64% in 1980 (Figure 6). The increase in the share in stationary fuel combustion and miscellaneous sectors was quite small.

TABLE 4 SUMMARY OF NATIONAL EMISSIONS (1970 to 1980) (x 10^3 t)

Year	Particulate	SO_2	NO_2	HC	CO
1970	2 027	6 678	1 329	1 873	11 586
1972	1 916	6 377	1 469	2 071	12 449
1974	2 077	5 880	1 558	2 021	12 312
1976	1 868	5 320	1 580	1 922	11 932
1978	1 889	4 516	1 685	1 995	12 153
1980	1 874	4 614	1 716	1 838	10 256
Change	-8%	-31%	+30%	-2%	-11%

The basically uncontrolled sources such as the miscellaneous, transportation and incineration categories exhibited a 34% increase of emissions commensurate with an overall increase in activity.

The non-utility (commercial, residential, industrial) stationary fuel combustion sectors are also largely uncontrolled. The decrease in emissions in this category was

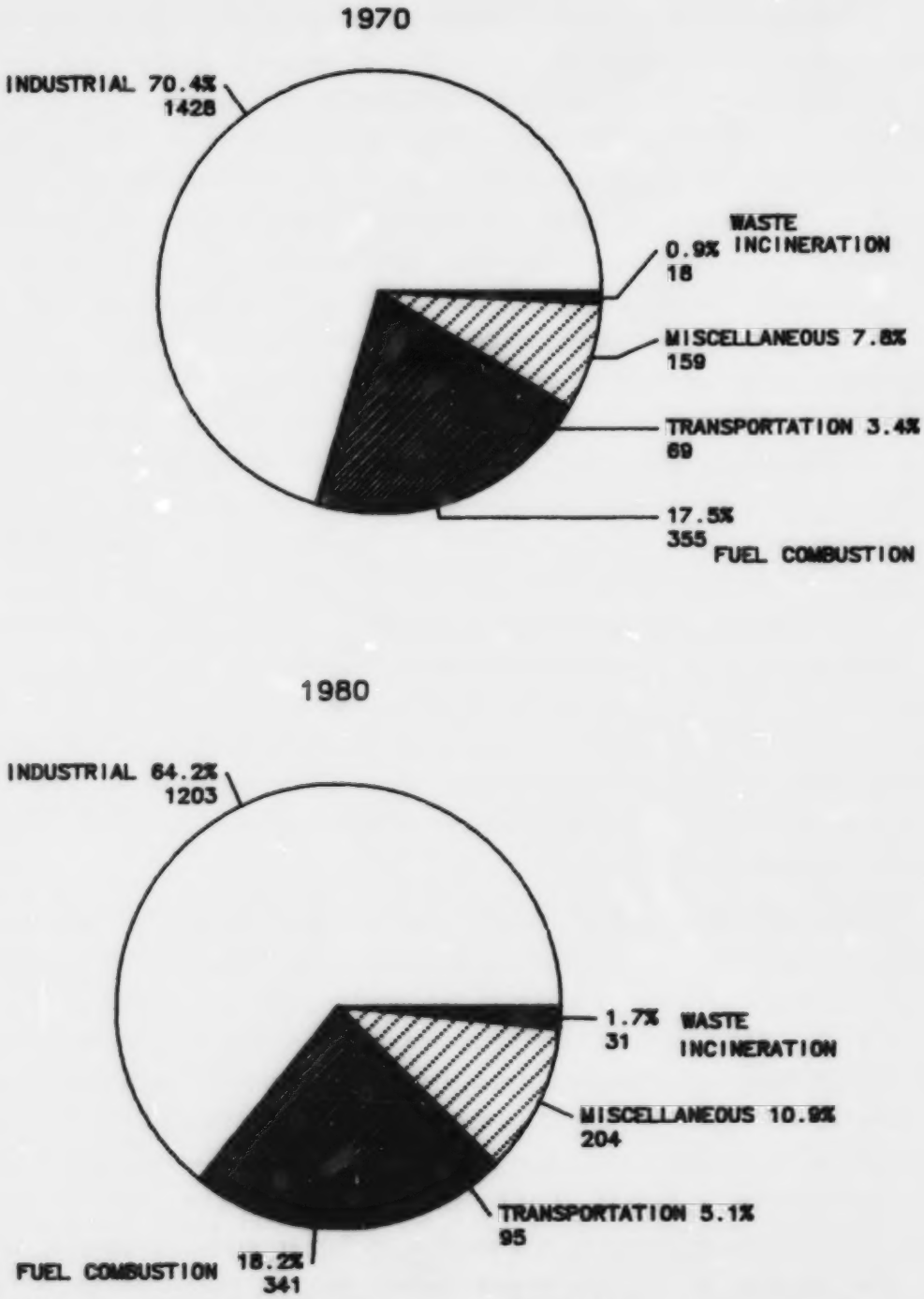


FIGURE 6 CHANGE IN DISTRIBUTION OF PARTICULATE EMISSIONS (1970 and 1980) (kilotonnes)

mainly due to changing fuel use patterns where oil, natural gas or electricity are replacing coal. In the residential fuel combustion sector most of the particulate emissions were attributable to an increasing use of wood as a heating fuel.

The particulate emissions from electric utilities increased 23%; however, during the same period, power generation from coal-fired plants increased 83%. The emissions did not increase proportionately with power generation because new plants were equipped with electrostatic precipitators and were using cleaner coal.

As shown in Table 5 the overall decrease in industrial particulate emissions was 28%. Three important sub-categories that registered significant decreases were: non-ferrous metals (36%); ferrous metals (35%); and mineral production (9%). The mineral production emission factors for some sectors were adjusted to account for fugitive particulate emissions that result from windblown dust from storage piles, overburden removal, and coal transportation. Because these fugitive emissions are large compared to process emissions, the overall reduction appears smaller than the reduction in process emissions alone.

The decreases in the particulate emissions from these sub-categories are a result of pollution abatement equipment (scrubbers, baghouses, electric precipitators) installed in the early 1970's. Although the production capacity of these operations was increasing generally, the world demand for smelter products was declining toward the end of the decade. The increase in emissions from the wood products sector generally reflects an increase in production. The "other" category emissions increased somewhat with all the industries controlled to varying degrees.

3.2.2 Sulphur Dioxide. Sulphur dioxide emissions come from two main source categories, industrial processes, and stationary fuel combustion. The sector that accounts for most of the SO_2 emitted is the non-ferrous smelting industry. Since 1970 SO_2 emissions from non-ferrous smelters have decreased by 45% (Table 6), this includes the emissions from primary copper, nickel, lead, zinc, and aluminum. In Figure 7, the industrial contribution to total SO_2 emissions decreased from 76% in 1970 to 67% in 1980. The stationary fuel combustion contribution to total SO_2 emissions rose from 23% in 1970 to 30% in 1980; however, in absolute terms emissions decreased by 11%. Non-utility fuel combustion SO_2 emissions decreased by 40% while utility SO_2 emissions increased by 52%.

The decrease in the non-ferrous sectors can be attributed to process improvements; closure of the Coniston smelter; increased pyrrhotite rejection at Thompson, Copper Cliff, and Falconbridge; the expansion of acid plants at INCO's Iron

TABLE 5 PARTICULATE EMISSIONS BY CATEGORY (x 10^3 t)

	1970	1972	1974	1976	1978	1980
Industrial						
Non-ferrous	173	172	160	107	122	111
Ferrous	463	293	303	288	261	290
Mining/mineral	470	497	585	414	383	393
Chemical	18	19	21	18	25	25
Fossil-fuel production	76	94	109	112	126	154
Wood and paper products	67	78	93	98	107	98
Other	160	205	206	185	186	131
Sub-total	1 427	1 358	1 477	1 222	1 210	1 202
Fuel Combustion						
Utilities	128	158	176	190	170	158
Residential	89	73	75	79	85	94
Commercial	16	18	14	9	8	7
Industrial	121	91	83	77	91	82
Sub-total	355	340	348	355	353	341
Transportation						
Light-duty vehicles	32	36	42	32	35	37
Heavy-duty vehicles	4	4	5	6	7	8
Diesel-powered engines	20	22	26	28	31	33
Off-road gas	3	3	2	2	2	2
Rail	6	7	7	6	7	7
Aircraft	1	1	1	1	2	2
Marine	3	7	5	5	5	6
Sub-total	69	80	88	80	89	95
Solid Waste	18	24	27	26	31	31
Miscellaneous	159	114	135	184	204	204
GRAND TOTAL	2 028	1 916	2 075	1 868	1 887	1 873

NOTE: does not include forest fires

Ore Recovery Plant (1974); and the addition of acid plants at Gaspé (1975) and Falconbridge (1978). The total emissions for 1978 and 1979 were less than normally expected due to the 8 1/2 month strike at INCO's Sudbury complex.(128) The Ontario government's regulation of SO_2 emissions (1980) restricted the Copper Cliff operation to 1 072 kt/yr.

TABLE 6 SULPHUR DIOXIDE EMISSIONS BY CATEGORY (x 10^3 t)

	1970	1972	1974	1976	1978	1980
Industrial						
Non-ferrous	3 885	3 306	2 952	2 623	1 839	2 133
Ferrous	157	172	197	174	164	173
Mining/mineral	-	-	-	-	-	-
Chemical	9	15	8	12	24	26
Fossil-fuel production	894	1 105	984	801	703	650
Wood and paper products	92	83	102	97	113	101
Other	8	8	7	10	8	7
Sub-total	5 045	4 689	4 250	3 717	2 851	3 090
Fuel Combustion						
Utilities	502	543	522	608	705	761
Residential	161	147	148	125	105	73
Commercial	209	238	180	121	107	90
Industrial	677	629	659	636	627	461
Sub-total	1 549	1 557	1 509	1 490	1 544	1 385
Transportation						
Light-duty vehicles	13	14	17	14	15	16
Heavy-duty vehicles	2	2	3	3	3	4
Diesel-powered engines	30	32	35	37	40	43
Off-road gas	2	2	2	2	1	1
Rail	3	4	4	3	4	4
Aircraft	1	1	2	2	3	2
Marine	33	75	60	53	52	66
Sub-total	84	130	123	114	118	136
Solid Waste	-	1	1	1	1	1
Miscellaneous	-	-	-	-	-	-
GRAND TOTAL	6 678	6 377	5 883	5 322	4 514	4 612

NOTE: does not include forest fires

The decrease in non-utility fuel combustion emissions can be attributed to regulation of the sulphur content of fuels, the decline in the use of coal for industrial and residential use and the general shift to cleaner fuels like natural gas and light oil.

The power utilities used additional low sulphur coal and introduced coal blending and coal washing. These measures served to limit the increase of sulphur dioxide

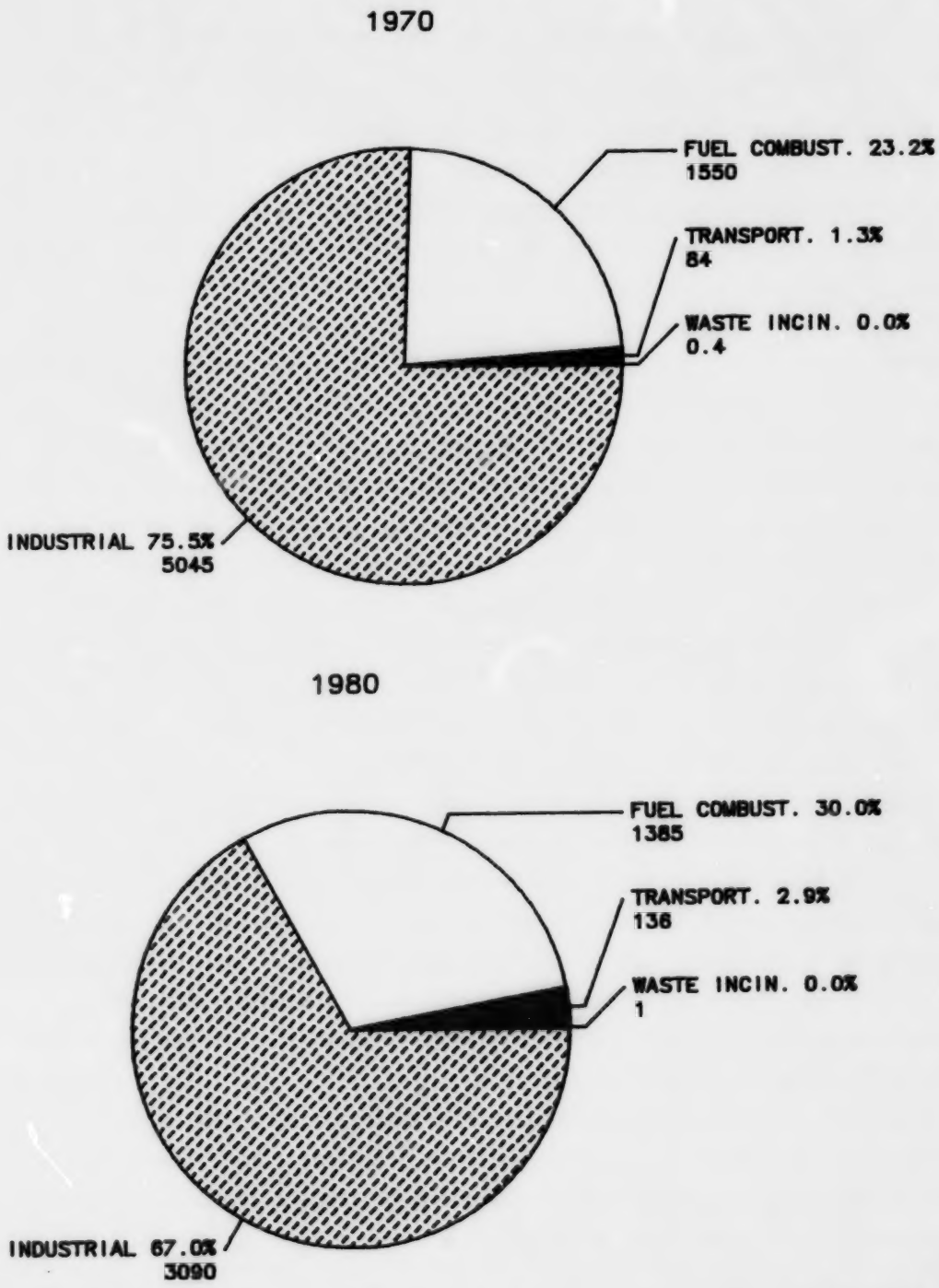


FIGURE 7 CHANGE IN THE DISTRIBUTION OF SULPHUR DIOXIDE EMISSIONS (1970 and 1980) (kilotonnes)

emissions to 52%, the total power generation from coal-fired plants increased by 83% during this time.(127)

3.2.3 Nitrogen Oxides. Nitrogen oxides (NOx) predominantly come from the transportation sectors and stationary fuel combustion. The relative amounts contributed by each category to total emissions have remained essentially the same (Figure 8). The 30% increase reflects the increase in energy demand and/or fuel consumed throughout the decade. Nitrogen oxides from stationary fuel combustion were largely uncontrolled.

Nitrogen oxide emissions from the gasoline-powered motor vehicle (mainly comprised of automobiles) sector increased from 1970 to 1980. From the data in Table 7 it is evident that the per year increase becomes progressively smaller from 1974 onward. This moderation of NO_x emissions is a direct result of the motor vehicle regulations that were enacted in the early 1970's. Exhaust gas recycling systems (EGR) were installed in new cars and light trucks to meet the legislated emission standards, and as the older, uncontrolled vehicles were removed from the total fleet by attrition, the "per vehicle" emission rate decreased. This trend, however, is offset by an increasing vehicle population which results in the moderated increase in the overall transportation category (36%) emissions and especially in the post 1974 period. It should be noted that a certain amount of tampering (misfuelling or otherwise malfunctioning) was taken into consideration in the derivation of emission factors. During this period the uncontrolled heavy vehicles such as trucks, diesel engines, railroad, aircraft and marine equipment accounted for a larger share of the total transportation category emissions.

The 20% increase in nitrogen oxide emissions from stationary fuel combustion was incurred mainly because of a 60% increase in utility emissions. Non-utility sector emissions (residential, industrial and commercial fuel combustion sources) despite a growing population, were unchanged from 1970 to 1980, while residential and commercial fuel combustion emissions decreased 15%. This reflects the change in fuel use patterns to cleaner fuels such as natural gas and electricity.

From 1970 to 1980, utilities such as Hydro-Québec and Ontario Hydro heavily promoted electricity for industrial and home use while government grant programs were instrumental in the rapid expansion and improvement of the gas pipeline distribution systems especially in central and Eastern Canada.

3.2.4 Hydrocarbons. Hydrocarbon (HC) emissions decreased marginally (2%) over the past decade (Table 4). The most significant decrease was achieved in the transportation category (25%) and particularly (31%) in gasoline-powered motor vehicles (Table 8).

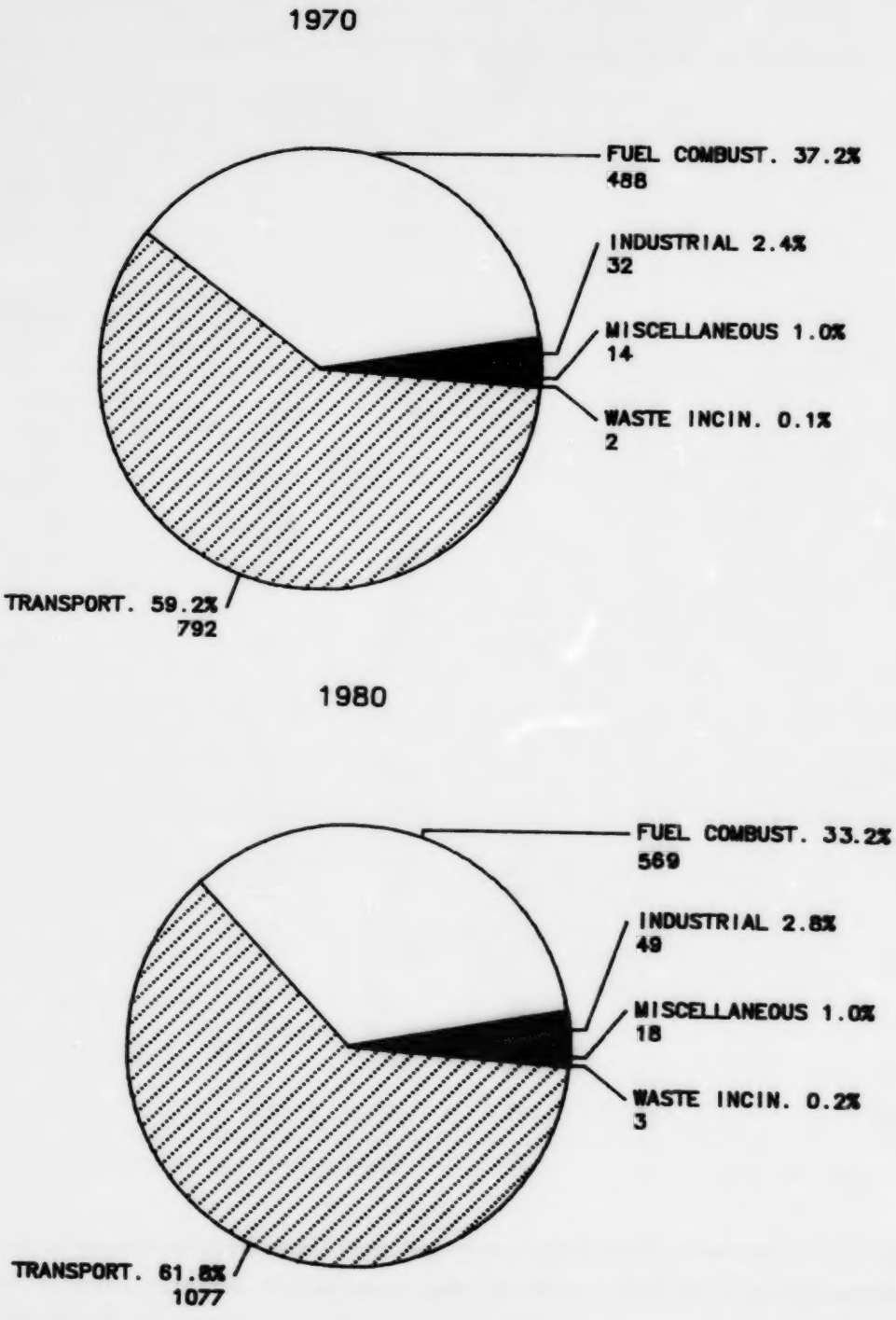


FIGURE 8 CHANGE IN DISTRIBUTION OF NITROGEN OXIDE EMISSIONS (1970 and 1980) (kilotonnes)

TABLE 7 NITROGEN OXIDE EMISSIONS BY CATEGORY (x 10^3 t)

	1970	1972	1974	1976	1978	1980
Industrial						
Non-ferrous	10	9	11	5	9	10
Ferrous	-	-	-	-	-	-
Mining/mineral	-	-	-	-	-	-
Chemical	6	7	14	7	8	9
Fossil-fuel production	6	8	8	8	9	15
Wood and paper products	10	11	14	15	17	15
Other	-	-	-	-	-	-
Sub-total	32	35	47	35	43	49
Fuel Combustion						
Utilities	149	163	164	197	198	231
Residential	57	59	60	55	53	50
Commercial	44	51	43	36	36	36
Industrial	238	257	285	259	274	252
Sub-total	488	529	552	548	561	569
Transportation						
Gasoline-powered motor vehicles	330	372	413	446	482	456
Diesel-powered engines	290	317	331	342	379	414
Off-road gas	52	51	38	38	32	27
Rail	88	96	101	92	100	107
Aircraft	19	24	35	37	44	42
Marine	14	32	26	24	23	31
Sub-total	793	892	944	979	1 060	1 077
Solid Waste	2	3	3	3	3	3
Miscellaneous	14	10	12	16	18	18
GRAND TOTAL	1 329	1 469	1 558	1 580	1 685	1 716

NOTE: does not include forest fires

The decreasing trend in automobile emissions began in 1974 and coincided with the introduction of oxidation catalysts. However, the main reason for the decrease in automobile HC emissions was the regulation of this pollutant under the Motor Vehicle Safety Act of 1971. Lower hydrocarbon emissions were initially achieved by adjusting the carburation, timing, and by injection of air into the exhaust manifold. In the mid to late

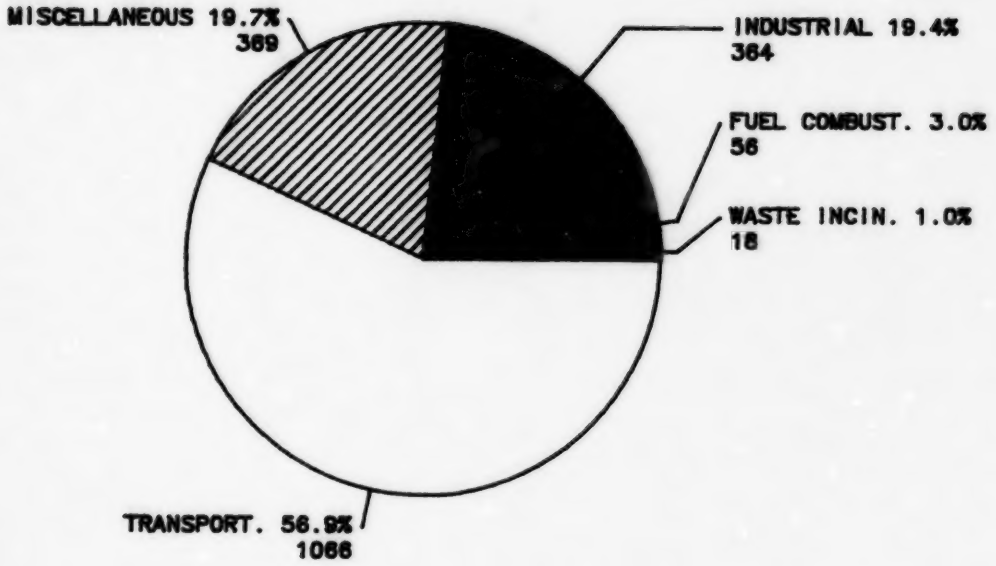
TABLE 8 HYDROCARBON EMISSIONS BY CATEGORY (x 10^3 t)

	1970	1972	1974	1976	1978	1980
Industrial						
Non-ferrous	1	1	1	1	1	1
Ferrous	-	-	-	-	-	-
Mining/mineral	-	-	-	-	-	-
Chemical	99	98	101	114	169	211
Fossil-fuel production	248	296	322	322	349	325
Wood and paper products	8	9	11	12	13	12
Other	10	10	13	16	20	20
Sub-total	366	414	458	465	552	569
Fuel Combustion						
Utilities	4	4	4	5	5	6
Residential	14	13	11	10	10	9
Commercial	2	2	2	2	2	2
Industrial	37	44	51	42	47	41
Sub-total	57	63	68	59	64	58
Transportation						
Gasoline-powered motor vehicles	899	992	879	745	752	622
Diesel-powered engines	33	36	38	40	43	46
Off-road gas	91	91	67	68	56	47
Rail	22	24	25	23	25	27
Aircraft	9	12	16	18	21	20
Marine	12	28	24	22	22	31
Sub-total	1 066	1183	1049	916	919	793
Solid Waste	18	22	26	25	30	30
Miscellaneous	369	391	420	457	430	388
GRAND TOTAL	1 876	2 073	2 021	1 922	1 995	1 838

NOTE: does not include forest fires

seventies new vehicles would meet the emissions standards by the addition of oxidation catalyst converters to the exhaust system. The reduction in gasoline-powered motor vehicle hydrocarbon emissions served to lower the share of the transportation category from about 55% in 1970 to 40% in 1980 despite a steadily increasing vehicle population (Figure 9).

1970



1980

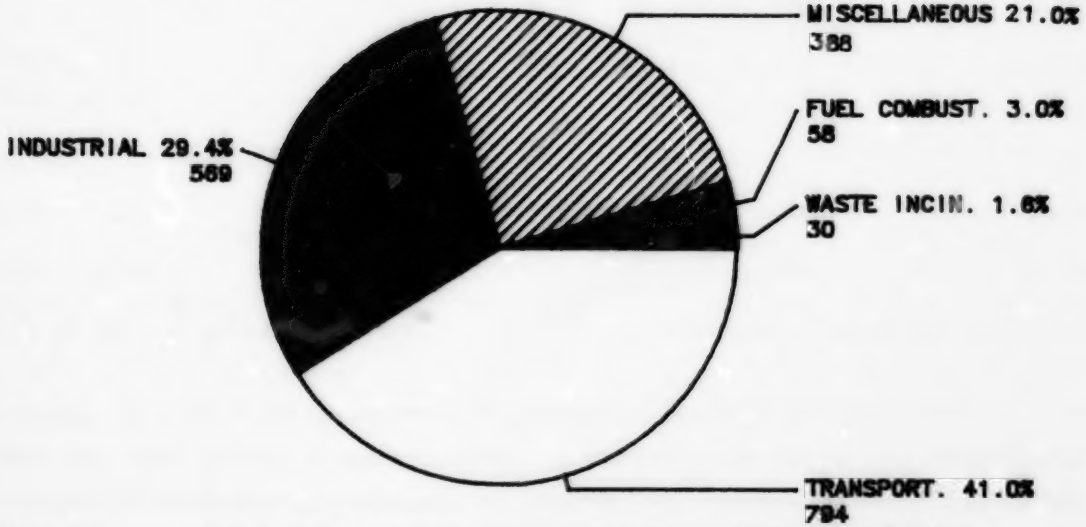


FIGURE 9 CHANGE IN DISTRIBUTION OF HYDROCARBON EMISSIONS (1970 and 1980) (kilotonnes)

In the industrial source category only fossil fuel processing shows a reduction in the year 1980. This can be explained, in part, by the decreasing trend in the number of storage tanks in use as well as the increasing use of new floating roof design tanks.

Generally as hydrocarbon emissions are uncontrolled they tend to increase according to the activity level associated with each sector. In Figure 9 the miscellaneous sectors show an increase from 18% in 1970 to 21% in 1980. This resulted from an increase in slash burning, dry cleaning and use of surface coatings. In the industrial category, the increased emissions from 1970 to 1980 reflect the increase of fugitive hydrocarbon emissions from such sectors as coal mines.

3.2.5 Carbon Monoxide. Total carbon monoxide (CO) emissions decreased 11% over the past decade (Table 4). The most prominant source, transportation, went from a 1970, 82% share of total CO to 76% in 1980, despite a growing vehicle population (Figure 10).

The onset of the decreasing trend in vehicle carbon monoxide emissions (Table 9) corresponds with the introduction of oxidation catalysts on new automobiles in 1974. The main reason, however, was the regulation limiting CO emissions in the Motor Vehicle Safety Act of 1971. There is always a lag time or latency period associated with the introduction of vehicle emission controls and decrease in emissions that is due to the everchanging vehicle fleet characteristics over time. All other transportation sectors show an increase in CO emissions comensurate with amount of fuel used.

Since carbon monoxide is generally uncontrolled (except by controlling combustion efficiency) in the stationary fuel combustion category the emission trends reflect the amount of fuel used and fuel use patterns. One notable example is the amount of fuel wood used in residential heating. Most of the CO emissions from residential fuel combustion come from fuel wood combustion and these emissions account for over 80% of the emissions from the entire fuel combustion category.

The increase in the solid waste incineration and miscellaneous categories reflect the increase in the amounts of slash burned and the amounts of wood waste burned in wigwam burners.

The 15% decrease in the industrial category results from the 48% decrease in the petroleum refining sector emissions. This decrease is attributed to increased use of carbon monoxide boilers and/or the use of promoter catalysts. The increased use of CO boilers was mainly the result of the refineries' efforts to reduce fuel consumption.

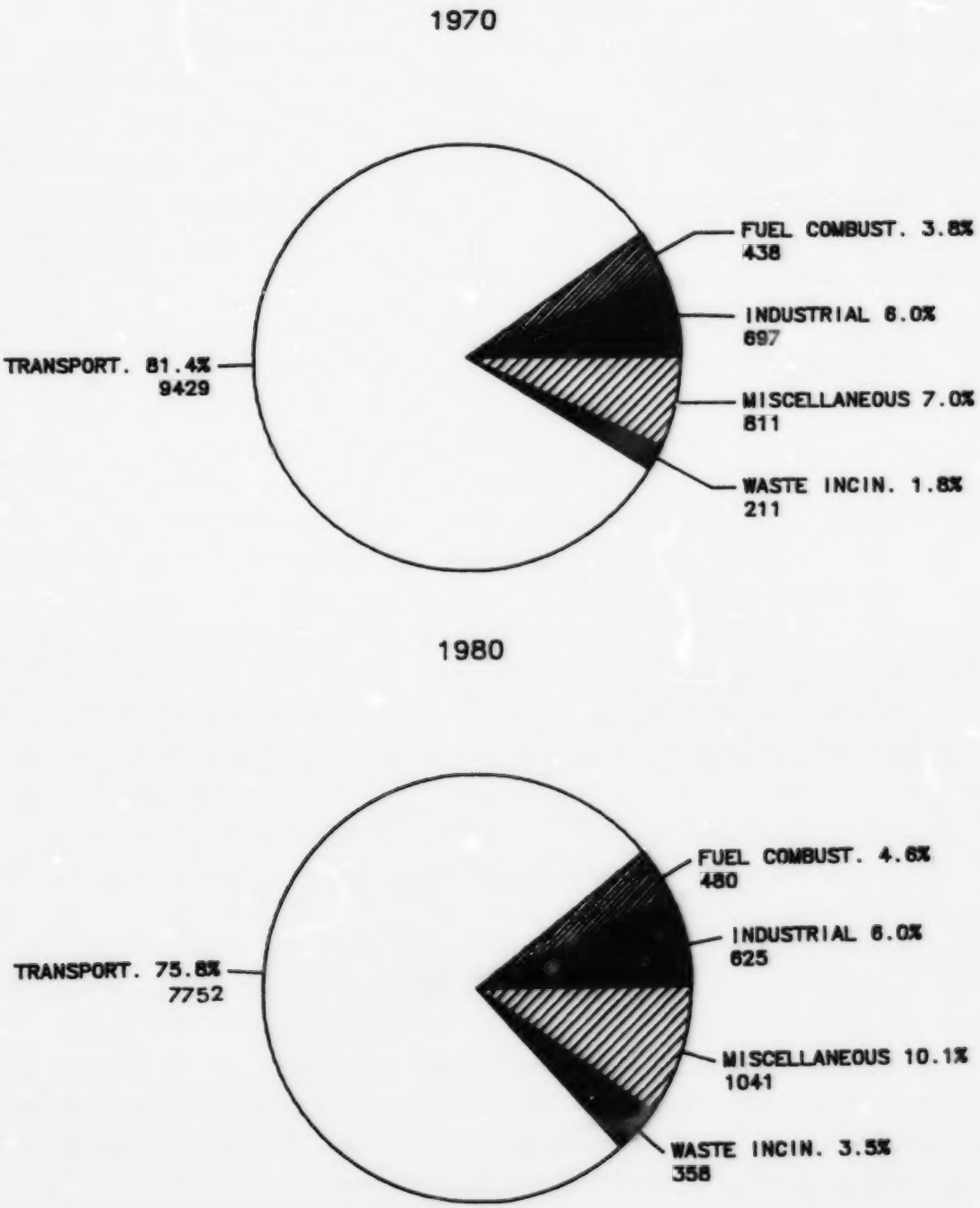


FIGURE 10 CHANGE IN DISTRIBUTION OF CARBON MONOXIDE EMISSIONS (1970 and 1980) (kilotonnes)

TABLE 9 CARBON MONOXIDE EMISSIONS BY CATEGORY (x 10^3 t)

	1970	1972	1974	1976	1978	1980
Industrial						
Non-ferrous	136	126	142	89	146	149
Ferrous	99	105	112	98	107	120
Mining/mineral	-	-	-	-	-	-
Chemical	80	80	83	120	130	112
Fossil-fuel production	338	423	483	458	444	179
Wood and paper products	38	45	55	58	64	59
Other	6	6	5	7	7	6
Sub-total	697	785	880	830	898	625
Fuel Combustion						
Utilities	13	13	14	18	18	21
Residential	382	315	316	341	370	412
Commercial	7	9	8	8	9	9
Industrial	35	35	38	34	37	38
Sub-total	437	372	376	401	434	480
Transportation						
Gasoline-powered motor vehicles	7 469	8 429	8 464	7 839	7 997	6 458
Diesel-powered engines	93	101	104	109	117	126
Off-road gas	1 718	1 710	1 266	1 278	1 051	888
Rail	32	35	37	34	36	39
Aircraft	89	107	135	158	168	165
Marine	27	66	57	53	54	76
Sub-total	9 428	10 448	10 063	9 471	9 423	7 752
Solid Waste	211	263	305	294	357	358
Miscellaneous	811	579	689	937	1 041	1 041
GRAND TOTAL	11 584	12 447	12 313	11 933	12 153	10 256

NOTE: does not include forest fires

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APPENDIX A
1980 PROVINCIAL EMISSIONS BY SECTOR

APPENDIX A - 1980 PROVINCIAL EMISSIONS BY SECTOR

TABLE A-1 NEWFOUNDLAND

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	65 077	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	-	-	-	-	-
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	-	-	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	-	-	-	-	-
Gold production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	-	-	-	-	-
Magnesium production	-	-	-	-	-
Asbestos production	5 896	-	-	-	-
Mining and rock quarrying	10 920	26	-	-	-
Salt production	-	-	-	-	-
Lime manufacturing	-	-	-	-	-
Gypsum processing	230	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Sodium carbonate processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	22	-	-	-	-
Stone processing	345	-	-	-	-
Sand and gravel processing	550	-	-	-	-
Cement manufacture	492	-	-	-	-
Concrete batching	38	-	-	-	-
Asphalt production	1 054	-	-	-	-
Glass manufacturing	-	-	-	-	-
Pigments production	-	-	-	-	-
Ammonium sulphate	-	-	-	-	-
Clay products manufacture	61	-	-	-	-
Crude oil production	-	-	-	164	-
Petroleum refining	-	-	-	1 913	-
Natural gas processing	-	-	-	-	-
Tar sands operations	-	-	-	-	-
Coal industry	-	-	-	-	-
Metallurgical coke manufacture	-	-	-	-	-
Petrochemical industry	-	-	-	-	-

TABLE A-1 NEWFOUNDLAND (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Plastics fabrication	-	-	-	-	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	-	-	-	-
Nitric acid production	-	-	-	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	621	-	-	-	-
Phosphate fertilizer manufacture	-	-	-	-	-
Elemental phosphorus production	6 044	1 168	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	-	-	-	-	-
Bakeries	-	-	-	41	-
Sulphate (kraft) pulping	-	-	-	-	-
Sulphite pulping	-	3 254	-	-	-
Sawmills	17	-	-	-	-
Pulpboard manufacture	-	-	-	-	-
Plywood and Veneer	6	-	-	-	-
SUBTOTAL	91 373	4 448	-	2 118	-
Fuel Combustion/Stationary Sources					
Power generation by utilities	1 460	17 997	3 563	208	761
Residential fuel combustion	125	1 972	795	122	302
Industrial fuel combustion	2 006	27 231	3 896	116	379
Commercial fuel combustion	157	2 455	600	17	120
Fuel wood combustion	7 006	207	418	264	31 275
SUBTOTAL	10 754	49 862	9 272	727	32 837
Transportation					
Gasoline-powered motor vehicles	799	330	7 521	11 610	111 991
Railroads	49	38	726	182	264
Marine	215	588	661	1 434	3 555
Aircraft	60	104	1 837	438	2 645
Off-road use of gasoline	6	5	97	172	3 246
Diesel-powered engines	885	1 085	11 593	1 143	3 193
Tire wear	55	-	-	11	-
SUBTOTAL	2 069	2 150	22 435	14 990	124 894

TABLE A-1 NEWFOUNDLAND (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Solid Waste Incineration					
Municipal incineration	-	-	-	-	-
Industrial and commercial incineration	18	11	12	4	13
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	68	1	6	68	799
SUBTOTAL	86	12	18	72	812
Miscellaneous					
Fertilizer application	10	-	-	-	-
Pesticide manufacturing and application	3	-	-	-	-
Gasoline and diesel marketing	-	-	-	2 745	-
Dry cleaning	-	-	-	387	-
Application of surface coatings	-	-	-	1 980	-
Structural fires	65	-	-	65	129
Cigarette smoking	113	-	-	-	45
General solvent use	-	-	-	1 788	-
Slash burning	3 658	-	325	352	18 625
SUBTOTAL	3 849	-	325	7 317	18 799
TOTAL	108 131	56 472	32 050	25 224	177 342

* Expressed as SO_2
** Expressed as NO_2

TABLE A-2 PRINCE EDWARD ISLAND

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	-	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	-	-	-	-	-
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	-	-	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	-	-	-	-	-
Gold production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	4	-	-	-	2
Magnesium production	-	-	-	-	-
Asbestos production	-	-	-	-	-
Mining and rock quarrying	-	-	-	-	-
Salt production	-	-	-	-	-
Lime manufacturing	-	-	-	-	-
Gypsum processing	-	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Sodium carbonate processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	-	-	-	-	-
Stone processing	-	-	-	-	-
Sand and gravel processing	60	-	-	-	-
Cement manufacture	-	-	-	-	-
Concrete batching	5	-	-	-	-
Asphalt production	1 148	-	-	-	-
Glass manufacturing	-	-	-	-	-
Pigments production	-	-	-	-	-
Ammonium sulphate	-	-	-	-	-
Clay products manufacture	-	-	-	-	-
Crude oil production	-	-	-	-	-
Petroleum refining	-	-	-	-	-
Natural gas processing	-	-	-	-	-
Tar sands operations	-	-	-	-	-
Coal industry	-	-	-	-	-
Metallurgical coke manufacture	-	-	-	-	-
Petrochemical industry	-	-	-	-	-

TABLE A-2 PRINCE EDWARD ISLAND (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Plastics fabrication	-	-	-	-	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	-	-	-	-
Nitric acid production	-	-	-	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	-	-	-	-	-
Phosphate fertilizer manufacture	-	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	-	-	-	-	-
Bakeries	-	-	-	4	-
Sulphate (kraft) pulping	-	-	-	-	-
Sulphite pulping	-	-	-	-	-
Sawmills	3	-	-	-	-
Pulpboard manufacture	-	-	-	-	-
Plywood and Veneer	-	-	-	-	-
SUBTOTAL	1 220	-	-	4	2
Fuel Combustion/Stationary Sources					
Power generation by utilities	152	1 989	442	6	34
Residential fuel combustion	37	646	278	36	76
Industrial fuel combustion	38	519	85	3	11
Commercial fuel combustion	132	991	170	110	513
Fuel wood combustion	1 559	-	93	59	6 959
SUBTOTAL	1 918	4 145	1 068	214	7 593
Transportation					
Gasoline-powered motor vehicles	231	105	2 405	3 145	34 963
Railroads	5	4	70	18	26
Marine	9	32	26	17	24
Aircraft	7	11	187	64	510
Off-road use of gasoline	12	9	197	349	6 569
Diesel-powered engines	137	208	1 568	207	571
Tire wear	18	-	-	4	-
SUBTOTAL	419	369	4 453	3 804	42 663

TABLE A-2 PRINCE EDWARD ISLAND (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Solid Waste Incineration					
Municipal incineration	-	-	-	-	-
Industrial and commercial incineration	5	3	3	1	3
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	25	-	2	25	300
SUBTOTAL	30	3	5	26	303
Miscellaneous					
Fertilizer application	116	-	-	-	-
Pesticide manufacturing and application	195	-	-	-	-
Gasoline and diesel marketing	-	-	-	771	-
Dry cleaning	-	-	-	84	-
Application of surface coatings	-	-	-	450	-
Structural fires	21	-	-	21	42
Cigarette smoking	24	-	-	-	10
General solvent use	-	-	-	386	-
Slash burning	364	-	32	35	1 853
SUBTOTAL	720	-	32	1 747	1 905
TOTAL	4 307	4 517	5 558	5 795	52 466

* Expressed as SO_2
** Expressed as NO_2

TABLE A-3 NOVA SCOTIA

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	-	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	27 372	715	-	-	-
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	-	-	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	-	-	-	-	-
Gold production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	144	-	-	-	25
Magnesium production	-	-	-	-	-
Asbestos production	-	-	-	-	-
Mining and rock quarrying	4 204	7	-	-	-
Salt production	1 652	-	-	-	-
Lime manufacturing	-	-	-	-	-
Gypsum processing	90	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Sodium carbonate processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	41	-	-	-	-
Stone processing	1 034	-	-	-	-
Sand and gravel processing	575	-	-	-	-
Cement manufacture	293	-	-	-	-
Concrete batching	43	-	-	-	-
Asphalt production	2 882	-	-	-	-
Glass manufacturing	-	-	-	-	-
Pigments production	-	-	-	-	-
Ammonium sulphate	-	-	-	-	-
Clay products manufacture	423	-	-	-	-
Crude oil production	-	-	-	1 728	-
Petroleum refining	314	6 321	428	8 338	11 003
Natural gas processing	-	-	-	-	-
Tar sands operations	-	-	-	-	-
Coal industry	304	-	-	12 698	-
Metallurgical coke manufacture	2 581	4 065	4	170	224
Petrochemical industry	-	-	-	635	-

TABLE A-3 NOVA SCOTIA (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Plastics fabrication	-	-	-	238	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	-	-	-	-
Nitric acid production	-	-	-	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	-	-	-	-	-
Phosphate fertilizer manufacture	-	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	244	-	-	-	-
Bakeries	-	-	-	100	-
Sulphate (kraft) pulping	3 953	487	331	180	1 267
Sulphite pulping	440	4 710	-	-	-
Sawmills	364	-	-	-	-
Pulpboard manufacture	100	-	-	8	-
Plywood and Veneer	-	-	-	-	-
SUBTOTAL	47 053	16 305	763	24 095	12 519
Fuel Combustion/Stationary Sources					
Power generation by utilities	12 606	125 231	30 958	367	1 364
Residential fuel combustion	652	8 197	2 176	674	2 608
Industrial fuel combustion	1 584	31 588	3 831	280	1 330
Commercial fuel combustion	585	8 232	1 457	44	212
Fuel wood combustion	4 824	143	288	182	21 532
SUBTOTAL	20 251	173 391	38 710	1 547	27 046
Transportation					
Gasoline-powered motor vehicles	1 777	801	18 266	24 483	266 392
Railroads	177	137	2 605	651	947
Marine	71	273	238	1 106	3 036
Aircraft	46	87	1 628	330	1 781
Off-road use of gasoline	10	7	159	282	5 299
Diesel-powered engines	1 029	1 588	12 751	1 489	4 310
Tire wear	134	-	-	27	-
SUBTOTAL	3 244	2 893	35 647	28 368	281 765

TABLE A-3 NOVA SCOTIA (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Solid Waste Incineration					
Municipal incineration	-	-	-	-	-
Industrial and commercial incineration	30	18	20	6	22
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	299	3	27	299	3 530
SUBTOTAL	329	21	47	305	3 552
Miscellaneous					
Fertilizer application	72	-	-	-	-
Pesticide manufacturing and application	72	-	-	-	-
Gasoline and diesel marketing	-	-	-	5 196	-
Dry cleaning	-	-	-	578	-
Application of surface coatings	-	-	-	3 126	-
Structural fires	210	-	-	210	420
Cigarette smoking	169	-	-	-	68
General solvent use	-	-	-	2 669	-
Slash burning	5 947	-	529	572	30 279
SUBTOTAL	6 470	-	529	12 351	30 767
TOTAL	77 347	192 610	75 696	66 666	355 649

* Expressed as SO_2
** Expressed as NO_2

TABLE A-4 NEW BRUNSWICK

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	-	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	-	-	-	-	-
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	-	-	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	813	12 826	-	-	-
Gold production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	14	-	-	-	4
Magnesium production	-	-	-	-	-
Asbestos production	-	-	-	-	-
Mining and rock quarrying	9 550	115	-	-	-
Salt production	-	-	-	-	-
Lime manufacturing	1 427	-	-	-	-
Gypsum processing	90	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Sodium carbonate processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	30	-	-	-	-
Stone processing	1 559	-	-	-	-
Sand and gravel processing	440	-	-	-	-
Cement manufacture	353	-	-	-	-
Concrete batching	43	-	-	-	-
Asphalt production	4 600	-	-	-	-
Glass manufacturing	33	-	-	-	-
Pigments production	-	-	-	-	-
Ammonium sulphate	-	-	-	-	-
Clay products manufacture	168	-	-	-	-
Crude oil production	-	-	-	2 534	-
Petroleum refining	248	4 699	279	7 012	36
Natural gas processing	-	-	-	-	-
Tar sands operations	-	-	-	-	-
Coal industry	955	-	-	1 329	-
Metallurgical coke manufacture	-	-	-	-	-
Petrochemical industry	-	-	-	-	-

TABLE A-4 NEW BRUNSWICK (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Plastics fabrication	-	-	-	190	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	-	-	-	-
Nitric acid production	-	-	-	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	429	-	-	-	-
Phosphate fertilizer manufacture	440	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	146	-	-	-	-
Bakeries	-	-	-	83	-
Sulphate (kraft) pulping	9 022	1 622	1 169	929	4 377
Sulphite pulping	-	26 023	-	-	-
Sawmills	1 352	-	-	-	-
Pulpboard manufacture	180	-	-	14	-
Plywood and Veneer	-	-	-	-	-
SUBTOTAL	31 892	45 285	1 448	12 091	4 417
Fuel Combustion/Stationary Sources					
Power generation by utilities	12 909	122 295	16 610	225	1 082
Residential fuel combustion	202	3 567	1 415	189	422
Industrial fuel combustion	2 738	37 965	6 422	148	667
Commercial fuel combustion	580	8 177	1 296	38	211
Fuel wood combustion	4 622	137	276	174	20 632
SUBTOTAL	21 051	172 141	26 019	774	23 014
Transportation					
Gasoline-powered motor vehicles	1 196	533	12 139	16 465	176 134
Railroads	105	81	1 544	386	562
Marine	56	285	203	651	1 741
Aircraft	35	41	527	884	9 423
Off-road use of gasoline	49	37	794	1 408	26 491
Diesel-powered engines	772	1 106	9 504	1 099	3 086
Tire wear	90	-	-	18	-
SUBTOTAL	2 303	2 083	24 711	20 911	217 437

TABLE A-4 NEW BRUNSWICK (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Solid Waste Incineration					
Municipal incineration	-	-	-	-	-
Industrial and commercial incineration	24	14	16	5	17
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	823	7	75	823	9 724
SUBTOTAL	847	21	91	828	9 741
Miscellaneous					
Fertilizer application	115	-	-	-	-
Pesticide manufacturing and application	152	-	-	-	-
Gasoline and diesel marketing	-	-	-	4 721	-
Dry cleaning	-	-	-	475	-
Application of surface coatings	-	-	-	2 529	-
Structural fires	136	-	-	136	272
Cigarette smoking	139	-	-	-	56
General solvent use	-	-	-	2 194	-
Slash burning	10 977	-	976	1 055	55 887
SUBTOTAL	11 519	-	976	11 110	56 215
TOTAL	67 612	219 530	53 245	45 714	310 824

* Expressed as SO_2
** Expressed as NO_2

TABLE A-5 QUEBEC

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	60 388	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	12 424	8 272	-	-	19 563
Primary aluminum production	31 744	39 638	7 703	1 037	96 859
Primary copper and nickel production	21 082	628 504	-	-	-
Copper and nickel refining	48	-	-	-	-
Primary lead and zinc production	1 852	12 397	-	-	-
Gold production	-	-	-	-	-
Ferroalloy manufacture	16 983	4 404	-	-	16 762
Abrasives manufacture	3 900	4 117	-	-	1 864
Ferrous foundries	2 942	-	-	-	806
Magnesium production	-	-	-	-	-
Asbestos production	35 025	-	-	-	-
Mining and rock quarrying	61 338	84	-	-	-
Salt production	-	-	-	-	-
Lime manufacturing	1 632	-	-	-	-
Gypsum processing	2 092	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Sodium carbonate processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	652	-	-	-	-
Stone processing	13 471	-	-	-	-
Sand and gravel processing	2 895	-	-	-	-
Cement manufacture	4 022	-	-	-	-
Concrete batching	426	-	-	-	-
Asphalt production	439	-	-	-	-
Glass manufacturing	329	-	-	-	-
Pigments production	147	2 905	-	-	-
Ammonium sulphate	-	-	-	-	-
Clay products manufacture	2 706	-	-	-	-
Crude oil production	-	-	-	765	-
Petroleum refining	2 619	13 167	1 186	43 302	4 753
Natural gas processing	-	-	-	-	-
Tar sands operations	-	-	-	-	-
Coal industry	-	-	-	-	-
Metallurgical coke manufacture	-	-	-	-	-
Petrochemical industry	-	-	-	17 311	-

TABLE A-5 QUEBEC (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Plastics fabrication	-	-	-	4 809	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	1 817	-	-	-
Nitric acid production	-	-	419	-	-
Phosphoric acid production	49	-	-	-	-
Phosphate rock processing	2 653	-	-	-	-
Phosphate fertilizer manufacture	-	-	-	-	-
Elemental phosphorus production	3 821	1 765	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	5 902	-	-	-	-
Bakeries	-	-	-	1 198	-
Sulphate (kraft) pulping	19 816	3 389	2 191	1 709	8 058
Sulphite pulping	-	29 750	-	-	-
Sawmills	10 107	-	-	-	-
Pulpboard manufacture	249	-	-	20	-
Plywood and Veneer	472	-	-	17	-
SUBTOTAL	322 225	750 209	11 499	70 168	148 665
Fuel Combustion/Stationary Sources					
Power generation by utilities	490	1 263	5 093	485	1 573
Residential fuel combustion	1 731	28 216	11 158	1 323	2 964
Industrial fuel combustion	16 948	208 283	40 176	1 004	5 577
Commercial fuel combustion	3 771	49 720	10 177	345	1 649
Fuel wood combustion	37 910	1 120	2 263	1 430	169 229
SUBTOTAL	60 850	288 602	68 867	4 587	180 992
Transportation					
Gasoline-powered motor vehicles	9 830	4 184	94 278	134 500	1 320 391
Railroads	879	619	12 914	3 229	4 696
Marine	3 651	46 064	17 038	9 137	18 721
Aircraft	270	429	7 230	3 267	27 083
Off-road use of gasoline	229	172	3 684	6 528	122 841
Diesel-powered engines	5 239	6 771	70 197	7 103	19 723
Tire wear	748	-	-	150	-
SUBTOTAL	20 846	58 239	205 341	163 914	1 513 455

TABLE A-5 QUEBEC (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Solid Waste Incineration					
Municipal incineration	1 103	666	740	372	8 941
Industrial and commercial incineration	243	146	158	49	175
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	5 419	49	493	5 419	64 039
SUBTOTAL	6 765	861	1 391	5 840	73 155
Miscellaneous					
Fertilizer application	915	-	-	-	-
Pesticide manufacturing and application	625	-	-	-	-
Gasoline and diesel marketing	-	-	-	33 280	-
Dry cleaning	-	-	-	4 391	-
Application of surface coatings	-	-	-	36 661	-
Structural fires	1 549	-	-	1 549	3 098
Cigarette smoking	1 283	-	-	-	513
General solvent use	-	-	-	20 281	-
Slash burning	41 472	-	3 689	3 988	211 147
SUBTOTAL	45 844	-	3 689	100 150	214 758
TOTAL	456 530	1 097 911	290 737	344 659	2 131 025

* Expressed as SO_2
** Expressed as NO_2

TABLE A-6 ONTARIO

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	32 773	160 713	-	-	34 056
Pyrrhotite roasting	427	65 806	-	-	-
Iron and steel production	33 682	1 922	-	-	36 773
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	16 285	868 619	-	-	-
Copper and nickel refining	3 199	1 349	-	-	-
Primary lead and zinc production	849	2 134	-	-	-
Gold production	208	15 144	-	-	-
Ferroalloy manufacture	1	8	-	-	-
Abrasives manufacture	4 425	3 658	-	-	4 460
Ferrous foundries	3 685	-	-	-	4 249
Magnesium production	308	-	-	-	-
Asbestos production	-	-	-	-	-
Mining and rock quarrying	37 332	284	-	-	-
Salt production	5 490	-	-	-	-
Lime manufacturing	15 382	-	-	-	-
Gypsum processing	4 148	-	-	-	-
Nepheline syenite processing	459	-	-	-	-
Sodium carbonate processing	960	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	615	-	-	-	-
Stone processing	13 081	-	-	-	-
Sand and gravel processing	607	-	-	-	-
Cement manufacture	2 471	-	-	-	-
Concrete batching	684	-	-	-	-
Asphalt production	7 166	-	-	-	-
Glass manufacturing	839	-	-	-	-
Pigments production	-	-	-	-	-
Ammonium sulphate	1	-	-	-	-
Clay products manufacture	6 573	-	-	-	-
Crude oil production	-	-	-	28	-
Petroleum refining	3 307	34 255	1 693	32 366	71 186
Natural gas processing	-	186	-	21	-
Tar sands operations	-	-	-	-	-
Coal industry	3 000	-	-	-	-
Metallurgical coke manufacture	17 779	4 956	19	1 439	1 330
Petrochemical industry	-	-	-	85 101	-

TABLE A-6 ONTARIO (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Plastics fabrication	-	-	-	10 069	-
Carbon black	15	1 671	-	58	112 012
Sulphuric acid production	-	4 299	-	-	-
Nitric acid production	-	-	1 310	-	-
Phosphoric acid production	322	-	-	-	-
Phosphate rock processing	1 222	-	-	-	-
Phosphate fertilizer manufacture	881	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	3 139	-	83	-	-
Grain handling and milling	16 692	-	-	-	-
Bakeries	-	-	-	1 368	-
Sulphate (kraft) pulping	17 414	5 111	3 476	2 715	13 289
Sulphite pulping	328	16 737	-	-	-
Sawmills	4 379	-	-	-	-
Pulpboard manufacture	584	-	-	47	-
Plywood and Veneer	847	-	-	30	-
SUBTOTAL	261 559	1 186 852	6 581	133 242	277 355
Fuel Combustion/Stationary Sources					
Power generation by utilities	12 663	397 751	101 262	1 624	5 462
Residential fuel combustion	1 489	19 408	17 168	1 830	5 288
Industrial fuel combustion	27 268	118 970	53 999	1 670	8 838
Commercial fuel combustion	1 465	11 822	10 096	597	2 800
Fuel wood combustion	24 668	729	1 472	931	110 118
SUBTOTAL	67 553	548 680	183 997	6 652	132 506
Transportation					
Gasoline-powered motor vehicles	15 128	6 621	149 965	204 097	2 115 129
Railroads	2 010	1 050	29 546	7 387	10 744
Marine	1 395	16 787	11 129	15 919	39 872
Aircraft	420	675	11 543	5 557	47 950
Off-road use of gasoline	352	265	5 672	10 051	189 126
Diesel-powered engines	6 744	9 922	84 607	9 760	27 526
Tire wear	1 163	-	-	233	-
SUBTOTAL	27 212	35 320	292 462	253 004	2 430 347

TABLE A-6 ONTARIO (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Solid Waste Incineration					
Municipal incineration	666	463	519	261	6 243
Industrial and commercial incineration	356	214	233	71	256
Sewage sludge incineration	259	976	293	73	-
Wigwam burners	3 004	27	273	3 004	35 499
SUBTOTAL	4 285	1 680	1 318	3 409	41 998
Miscellaneous					
Fertilizer application	1 621	-	-	-	-
Pesticide manufacturing and application	3 804	-	-	-	-
Gasoline and diesel marketing	-	-	-	51 050	-
Dry cleaning	-	-	-	5 882	-
Application of surface coatings	-	-	-	64 634	-
Structural fires	1 702	-	-	1 702	3 406
Cigarette smoking	1 718	-	-	-	687
General solvent use	-	-	-	27 169	-
Slash burning	27 906	-	2 482	2 683	142 079
SUBTOTAL	36 751	-	2 482	153 120	146 172
TOTAL	397 360	1 772 532	486 840	549 427	3 028 378

* Expressed as SO_2
** Expressed as NO_2

TABLE A-7 MANITOBA

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	-	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	468	-	-	-	261
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	13 281	392 650	-	-	-
Copper and nickel refining	16	-	-	-	-
Primary lead and zinc production	4 008	69 957	-	-	-
Gold production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	1 028	-	-	-	-
Magnesium production	-	-	-	-	-
Asbestos production	-	-	-	-	-
Mining and rock quarrying	4 730	79	-	-	-
Salt production	-	-	-	-	-
Lime manufacturing	1 041	-	-	-	-
Gypsum processing	242	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Sodium carbonate processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	829	-	-	-	-
Stone processing	563	-	-	-	-
Sand and gravel processing	910	-	-	-	-
Cement manufacture	498	-	-	-	-
Concrete batching	79	-	-	-	-
Asphalt production	3 291	-	-	-	-
Glass manufacturing	-	-	-	-	-
Pigments production	-	-	-	-	-
Ammonium sulphate	-	-	-	-	-
Clay products manufacture	36	-	-	-	-
Crude oil production	-	-	-	172	-
Petroleum refining	109	3 762	97	3 390	1 933
Natural gas processing	-	-	-	-	-
Tar sands operations	-	-	-	-	-
Coal industry	4 350	-	-	-	-
Metallurgical coke manufacture	-	-	-	-	-
Petrochemical industry	-	-	-	4 014	-

TABLE A-7 MANITOBA (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Plastics fabrication	-	-	-	714	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	512	-	-	-
Nitric acid production	-	-	211	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	-	-	-	-	-
Phosphate fertilizer manufacture	115	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	255	-	22	-	-
Grain handling and milling	12 920	-	-	-	-
Bakeries	-	-	-	148	-
Sulphate (kraft) pulping	361	1 158	229	179	877
Sulphite pulping	-	1 933	-	-	-
Sawmills	294	-	-	-	-
Pulpboard manufacture	-	-	-	-	-
Plywood and Veneer	-	-	-	-	-
SUBTOTAL	49 424	470 051	559	8 617	3 071
Fuel Combustion/Stationary Sources					
Power generation by utilities	4 859	2 812	2 303	114	373
Residential fuel combustion	92	609	1 477	142	481
Industrial fuel combustion	1 309	5 268	2 880	73	766
Commercial fuel combustion	673	674	1 414	556	471
Fuel wood combustion	1 962	58	117	74	8 760
SUBTOTAL	8 895	9 421	8 191	959	10 851
Transportation					
Gasoline-powered motor vehicles	2 258	1 003	22 860	31 265	333 674
Railroads	836	569	12 280	3 070	4 466
Marine	1	10	10	1 317	3 870
Aircraft	95	164	2 967	842	5 647
Off-road use of gasoline	213	160	3 430	6 079	114 384
Diesel-powered engines	1 644	2 230	18 440	2 384	6 355
Tire wear	168	-	-	34	-
SUBTOTAL	5 215	4 136	59 987	44 991	468 396

TABLE A-7 MANITOBA (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Solid Waste Incineration					
Municipal incineration	-	-	-	-	-
Industrial and commercial incineration	40	24	26	8	29
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	191	2	17	191	2 258
SUBTOTAL	231	26	43	199	2 287
Miscellaneous					
Fertilizer application	1 235	-	-	-	-
Pesticide manufacturing and application	5 140	-	-	-	-
Gasoline and diesel marketing	-	-	-	5 475	-
Dry cleaning	-	-	-	700	-
Application of surface coatings	-	-	-	3 977	-
Structural fires	277	-	-	277	555
Cigarette smoking	204	-	-	-	82
General solvent use	-	-	-	3 233	-
Slash burning	3 056	-	272	294	15 559
SUBTOTAL	9 912	-	272	13 956	16 196
TOTAL	73 677	483 634	69 052	68 722	500 801

* Expressed as SO_2
** Expressed as NO_2

TABLE A-8 SASKATCHEWAN

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	-	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	2 173	-	-	-	3 629
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	-	-	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	-	-	-	-	-
Gold production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	9	-	-	-	-
Magnesium production	-	-	-	-	-
Asbestos production	-	-	-	-	-
Mining and rock quarrying	2 310	-	-	-	-
Salt production	643	-	-	-	-
Lime manufacturing	-	-	-	-	-
Gypsum processing	2 475	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Sodium carbonate processing	-	-	-	-	-
Potash processing	15 007	-	-	-	-
Silica processing	57	-	-	-	-
Stone processing	-	-	-	-	-
Sand and gravel processing	740	-	-	-	-
Cement manufacture	1 289	-	-	-	-
Concrete batching	114	-	-	-	-
Asphalt production	3 572	-	-	-	-
Glass manufacturing	-	-	-	-	-
Pigments production	-	-	-	-	-
Ammonium sulphate	-	-	-	-	-
Clay products manufacture	343	-	-	-	-
Crude oil production	-	-	-	2 846	-
Petroleum refining	394	3 744	134	8 605	-
Natural gas processing	-	4 703	-	53	-
Tar sands operations	-	-	-	-	-
Coal industry	6 974	-	-	21 349	-
Metallurgical coke manufacture	1 966	640	52	181	155
Petrochemical industry	-	-	-	-	-

TABLE A-8 SASKATCHEWAN (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Plastics fabrication	-	-	-	286	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	529	-	-	-
Nitric acid production	-	-	-	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	-	-	-	-	-
Phosphate fertilizer manufacture	-	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	15 999	-	-	-	-
Bakeries	-	-	-	74	-
Sulphate (kraft) pulping	2 826	438	298	232	1 138
Sulphite pulping	-	-	-	-	-
Sawmills	471	-	-	-	-
Pulpboard manufacture	71	-	-	6	-
Plywood and Veneer	141	-	-	5	-
SUBTOTAL	57 574	10 054	484	33 637	4 922
Fuel Combustion/Stationary Sources					
Power generation by utilities	86 835	31 584	9 394	744	2 383
Residential fuel combustion	420	870	2 204	306	1 196
Industrial fuel combustion	3 698	5 076	6 863	146	1 393
Commercial fuel combustion	147	175	1 001	88	404
Fuel wood combustion	2 183	64	130	82	9 743
SUBTOTAL	93 283	37 769	19 592	1 366	15 119
Transportation					
Gasoline-powered motor vehicles	2 474	1 146	26 354	34 461	395 639
Railroads	407	928	5 984	1 496	2 176
Marine	-	10	10	1 779	5 233
Aircraft	102	182	3 529	845	7 204
Off-road use of gasoline	408	307	6 568	11 639	219 010
Diesel-powered engines	3 555	4 111	35 777	5 041	12 434
Tire wear	184	-	-	37	-
SUBTOTAL	7 130	6 684	78 222	55 298	641 696

TABLE A-8 SASKATCHEWAN (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Solid Waste Incineration					
Municipal incineration	19	5	-	-	32
Industrial and commercial incineration	36	22	24	7	26
Sewage sludge incineration	1	-	2	-	-
Wigwam burners	279	3	25	279	3 294
SUBTOTAL	335	30	51	286	3 352
Miscellaneous					
Fertilizer application	1 156	-	-	-	-
Pesticide manufacturing and application	9 797	-	-	-	-
Gasoline and diesel marketing	-	-	-	6 168	-
Dry cleaning	-	-	-	660	-
Application of surface coatings	-	-	-	3 683	-
Structural fires	187	-	-	187	374
Cigarette smoking	193	-	-	-	77
General solvent use	-	-	-	3 050	-
Slash burning	4 358	-	388	419	22 189
SUBTOTAL	15 691	-	388	14 167	22 640
TOTAL	174 013	54 537	98 737	104 754	687 729

* Expressed as SO_2
** Expressed as NO_2

TABLE A-9 ALBERTA

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	-	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	545	-	-	-	2 389
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	-	-	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	-	-	-	-	-
Gold production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	192	-	-	-	81
Magnesium production	-	-	-	-	-
Asbestos production	-	-	-	-	-
Mining and rock quarrying	790	-	-	-	-
Salt production	138	-	-	-	-
Lime manufacturing	714	-	-	-	-
Gypsum processing	717	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Sodium carbonate processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	242	-	-	-	-
Stone processing	123	-	-	-	-
Sand and gravel processing	1 600	-	-	-	-
Cement manufacture	951	-	-	-	-
Concrete batching	425	-	-	-	-
Asphalt production	3 053	-	-	-	-
Glass manufacturing	70	-	-	-	-
Pigments production	-	-	-	-	-
Ammonium sulphate	35	-	-	-	-
Clay products manufacture	759	-	-	-	-
Crude oil production	-	32 850	-	19 274	-
Petroleum refining	1 308	6 170	1 149	17 449	640
Natural gas processing	-	315 448	-	5 762	-
Tar sands operations	22 602	149 600	9 620	18	287
Coal industry	7 976	-	-	66 018	-
Metallurgical coke manufacture	-	-	-	-	-
Petrochemical industry	-	-	-	99 136	-

TABLE A-9 ALBERTA (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Plastics fabrication	-	-	-	1 166	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	8 030	-	-	-
Nitric acid production	-	-	4 943	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	2 430	-	-	-	-
Phosphate fertilizer manufacture	2 183	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	3 036	-	68	-	-
Grain handling and milling	10 909	-	-	-	-
Bakeries	-	-	-	280	-
Sulphate (kraft) pulping	2 945	6 641	727	568	2 778
Sulphite pulping	-	-	-	-	-
Sawmills	2 079	-	-	-	-
Pulpboard manufacture	45	-	-	4	-
Plywood and Veneer	514	-	-	18	-
SUBTOTAL	66 381	518 739	16 507	209 693	6 175
Fuel Combustion/Stationary Sources					
Power generation by utilities	15 272	66 124	52 899	1 602	5 614
Residential fuel combustion	826	944	4 457	1 170	5 543
Industrial fuel combustion	808	991	133 482	44 880	17 627
Commercial fuel combustion	254	296	6 918	539	2 375
Fuel wood combustion	1 247	37	74	47	5 567
SUBTOTAL	18 407	68 392	197 830	48 238	36 726
Transportation					
Gasoline-powered motor vehicles	5 589	2 527	57 634	76 788	840 350
Railroads	2 029	555	29 814	7 454	10 842
Marine	-	14	14	2 359	6 939
Aircraft	234	353	5 744	3 003	22 985
Off-road use of gasoline	202	152	3 249	5 758	108 351
Diesel-powered engines	7 318	8 582	88 531	10 068	26 007
Tire wear	424	-	-	85	-
SUBTOTAL	15 796	12 183	184 986	105 515	1 015 474

TABLE A-9 ALBERTA (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Solid Waste Incineration					
Municipal incineration	-	-	-	-	-
Industrial and commercial incineration	95	57	62	19	68
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	1 154	10	105	1 154	13 639
SUBTOTAL	1 249	67	167	1 173	13 707
Miscellaneous					
Fertilizer application	1 640	-	-	-	-
Pesticide manufacturing and application	6 687	-	-	-	-
Gasoline and diesel marketing	-	-	-	16 798	-
Dry cleaning	-	-	-	1 526	-
Application of surface coatings	-	-	-	8 051	-
Structural fires	527	-	-	527	1 053
Cigarette smoking	446	-	-	-	178
General solvent use	-	-	-	7 049	-
Slash burning	8 795	-	782	846	44 779
SUBTOTAL	18 095	-	782	34 797	46 010
TOTAL	119 928	599 381	400 272	399 416	1 118 092

* Expressed as SO_2
** Expressed as NO_2

TABLE A-10 BRITISH COLUMBIA

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	310	-	-	-	-
Pyrrhotite roasting	176	3 796	-	-	-
Iron and steel production	407	-	-	-	1 080
Primary aluminum production	9 423	6 143	2 155	433	37 756
Primary copper and nickel production	129	8 500	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	4 183	21 723	-	-	-
Gold production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	234	-	-	-	33
Magnesium production	-	-	-	-	-
Asbestos production	8 182	-	-	-	-
Mining and rock quarrying	66 652	-	-	-	-
Salt production	-	-	-	-	-
Lime manufacturing	2 709	-	-	-	-
Gypsum processing	1 269	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Sodium carbonate processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	1	-	-	-	-
Stone processing	1 641	-	-	-	-
Sand and gravel processing	2 560	-	-	-	-
Cement manufacture	1 402	-	-	-	-
Concrete batching	336	-	-	-	-
Asphalt production	5 834	-	-	-	-
Glass manufacturing	139	-	-	-	-
Pigments production	-	-	-	-	-
Ammonium sulphate	56	-	-	-	-
Clay products manufacture	443	-	-	-	-
Crude oil production	-	-	-	612	-
Petroleum refining	588	5 903	655	11 320	84 021
Natural gas processing	-	63 624	-	10	-
Tar sands operations	-	-	-	-	-
Coal industry	79 776	-	-	52 412	-
Metallurgical coke manufacture	643	236	1	32	42
Petrochemical industry	-	-	-	5 100	-

TABLE A-10 BRITISH COLUMBIA (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Plastics fabrication	-	-	-	1 904	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	705	-	-	-
Nitric acid production	-	-	-	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	1 068	-	-	-	-
Phosphate fertilizer manufacture	342	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	789	-	-	-	-
Bakeries	-	-	-	362	-
Sulphate (kraft) pulping	50 568	10 991	7 474	5 786	28 576
Sulphite pulping	342	3 079	-	-	-
Sawmills	36 138	-	-	-	-
Pulpboard manufacture	217	-	-	17	-
Plywood and Veneer	4 396	-	-	156	-
SUBTOTAL	280 953	124 700	10 285	78 144	151 508
Fuel Combustion/Stationary Sources					
Power generation by utilities	135	205	2 995	142	557
Residential fuel combustion	305	2 954	3 593	367	1 112
Industrial fuel combustion	4 661	23 750	15 150	967	2 097
Commercial fuel combustion	453	3 040	2 938	181	804
Fuel wood combustion	1 218	36	73	46	5 438
SUBTOTAL	6 772	29 985	24 749	1 703	10 008
Transportation					
Gasoline-powered motor vehicles	5 657	2 540	57 901	77 509	840 585
Railroads	789	251	11 590	2 897	4 214
Marine	601	1 618	1 858	6 461	17 144
Aircraft	241	339	5 006	4 136	34 693
Off-road use of gasoline	154	116	2 477	4 389	82 590
Diesel-powered engines	5 526	7 165	74 006	7 331	20 724
Tire wear	429	-	-	86	-
SUBTOTAL	13 397	12 029	152 838	102 809	999 950

TABLE A-10 BRITISH COLUMBIA (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Solid Waste Incineration					
Municipal incineration	206	46	9	6	342
Industrial and commercial incineration	111	66	72	22	80
Sewage sludge incineration	30	6	6	2	-
Wigwam burners	18 966	172	1 724	18 966	224 140
SUBTOTAL	19 313	290	1 811	18 996	224 562
Miscellaneous					
Fertilizer application	246	-	-	-	-
Pesticide manufacturing and application	241	-	-	-	-
Gasoline and diesel marketing	-	-	-	17 102	-
Dry cleaning	-	-	-	1 872	-
Application of surface coatings	-	-	-	16 307	-
Structural fires	367	-	-	367	734
Cigarette smoking	547	-	-	-	219
General solvent use	-	-	-	8 645	-
Slash burning	97 707	-	8 690	9 395	497 458
SUBTOTAL	99 108	-	8 690	53 688	498 411
TOTAL	419 543	167 004	198 373	255 340	1 884 439

* Expressed as SO_2
** Expressed as NO_2

TABLE A-11 NORTHWEST TERRITORIES/YUKON

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	-	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	-	-	-	-	-
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	-	-	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	-	-	-	-	-
Gold production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	-	-	-	-	-
Magnesium production	-	-	-	-	-
Asbestos production	-	-	-	-	-
Mining and rock quarrying	5 994	87	-	-	-
Salt production	-	-	-	-	-
Lime manufacturing	-	-	-	-	-
Gypsum processing	-	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Sodium carbonate processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	-	-	-	-	-
Stone processing	-	-	-	-	-
Sand and gravel processing	-	-	-	-	-
Cement manufacture	-	-	-	-	-
Concrete batching	2	-	-	-	-
Asphalt production	55	-	-	-	-
Glass manufacturing	-	-	-	-	-
Pigments production	-	-	-	-	-
Ammonium sulphate	-	-	-	-	-
Clay products manufacture	-	-	-	-	-
Crude oil production	-	-	-	49	-
Petroleum refining	-	40	-	-	-
Natural gas processing	-	-	-	1	-
Tar sands operations	-	-	-	-	-
Coal industry	-	-	-	-	-
Metallurgical coke manufacture	-	-	-	-	-
Petrochemical industry	-	-	-	-	-

TABLE A-11 NORTHWEST TERRITORIES/YUKON (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Plastics fabrication	-	-	-	-	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	-	-	-	-
Nitric acid production	-	-	-	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	-	-	-	-	-
Phosphate fertilizer manufacture	-	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	-	-	-	-	-
Bakeries	-	-	-	1	-
Sulphate (kraft) pulping	-	-	-	-	-
Sulphite pulping	-	-	-	-	-
Sawmills	30	-	-	-	-
Pulpboard manufacture	-	-	-	-	-
Plywood and Veneer	-	-	-	-	-
SUBTOTAL	6 081	127	-	51	-
Fuel Combustion/Stationary Sources					
Power generation by utilities	295	476	3 283	316	1 025
Residential fuel combustion	10	109	95	11	26
Industrial fuel combustion	32	242	180	4	38
Commercial fuel combustion	37	412	268	8	64
Fuel wood combustion	770	-	46	29	3 439
SUBTOTAL	1 144	1 239	3 872	368	4 592
Transportation					
Gasoline-powered motor vehicles	133	64	1 474	1 918	23 104
Railroads	7	4	110	28	40
Marine	2	4	5	3	4
Aircraft	71	95	1 528	492	5 242
Off-road use of gasoline	18	14	294	522	9 815
Diesel-powered engines	533	585	7 332	647	1 798
Tire wear	10	-	-	2	-
SUBTOTAL	774	766	10 743	3 612	40 003

TABLE A-11 NORTHWEST TERRITORIES/YUKON (Cont'd)

	Emissions (tonnes)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Solid Waste Incineration					
Municipal incineration	-	-	-	-	-
Industrial and commercial incineration	3	2	2	1	2
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	27	-	2	27	315
SUBTOTAL	30	2	4	28	317
Miscellaneous					
Fertilizer application	-	-	-	-	-
Pesticide manufacturing and application	-	-	-	-	-
Gasoline and diesel marketing	-	-	-	351	-
Dry cleaning	-	-	-	47	-
Application of surface coatings	-	-	-	243	-
Structural fires	16	-	-	16	32
Cigarette smoking	14	-	-	-	5
General solvent use	-	-	-	217	-
Slash burning	151	-	13	14	766
SUBTOTAL	181	-	13	888	803
TOTAL	8 210	2 173	14 632	4 946	45 715

* Expressed as SO_2
** Expressed as NO_2

APPENDIX B
EMISSION TRENDS

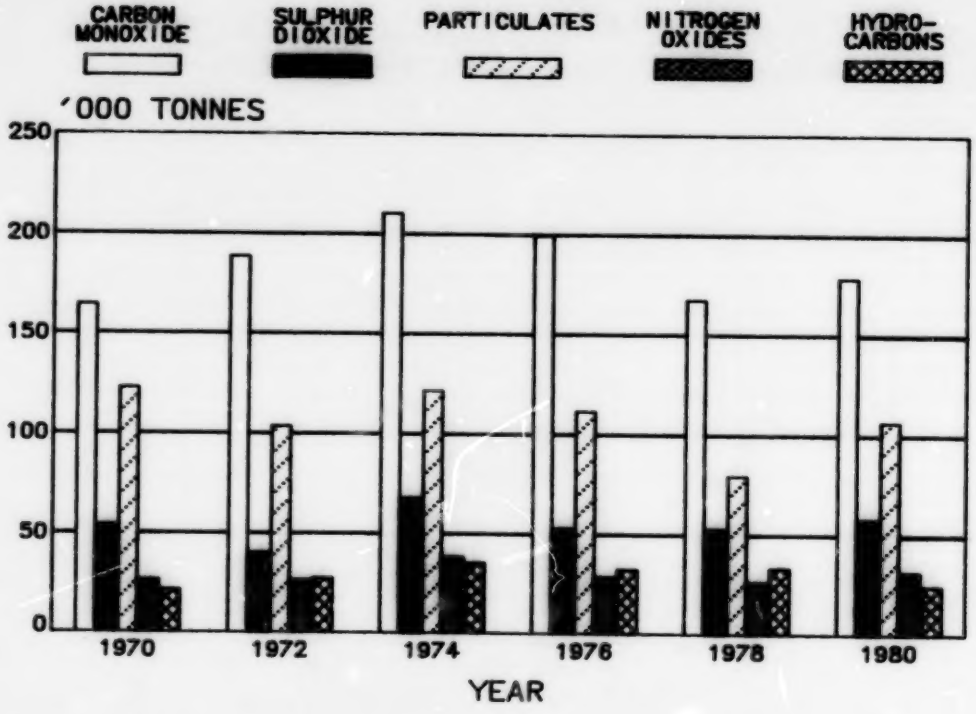

FIGURE B-1 NEWFOUNDLAND

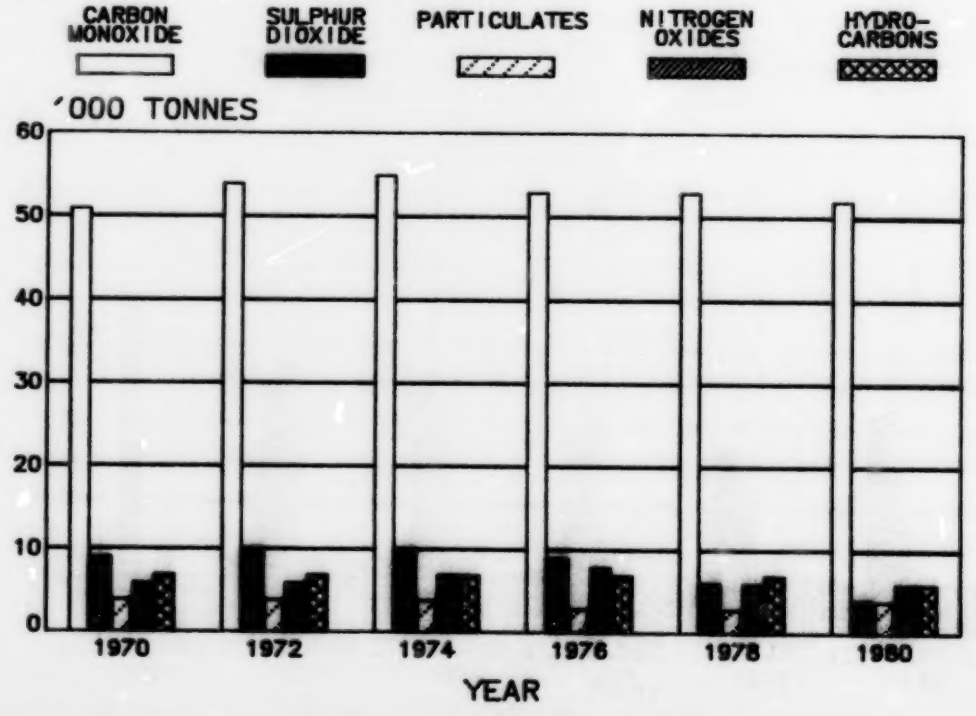

FIGURE B-2 PRINCE EDWARD ISLAND

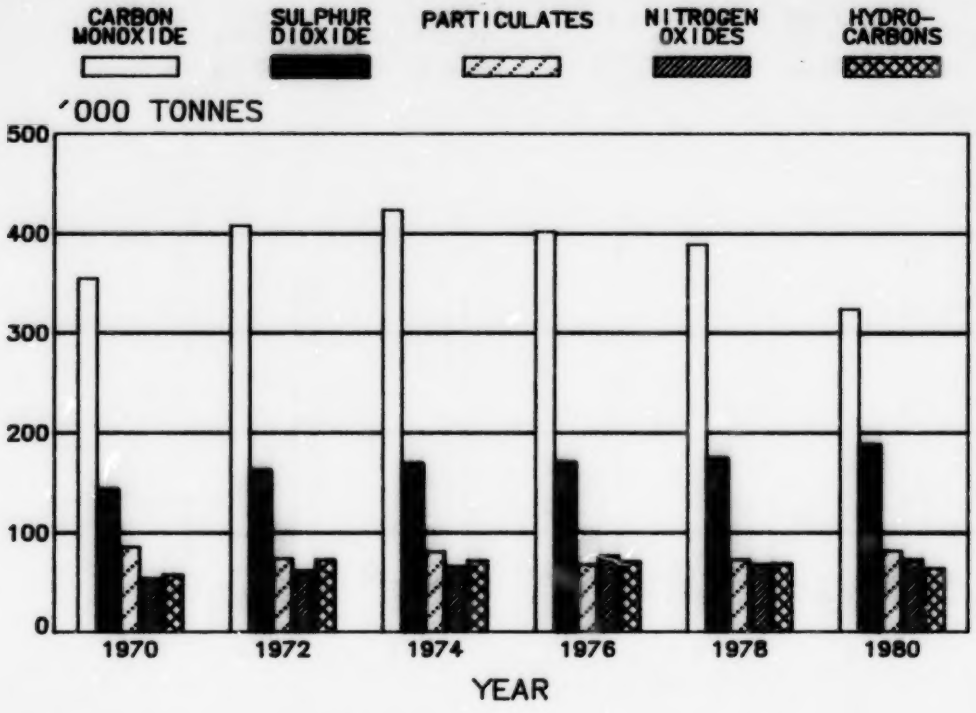

FIGURE B-3 NOVA SCOTIA

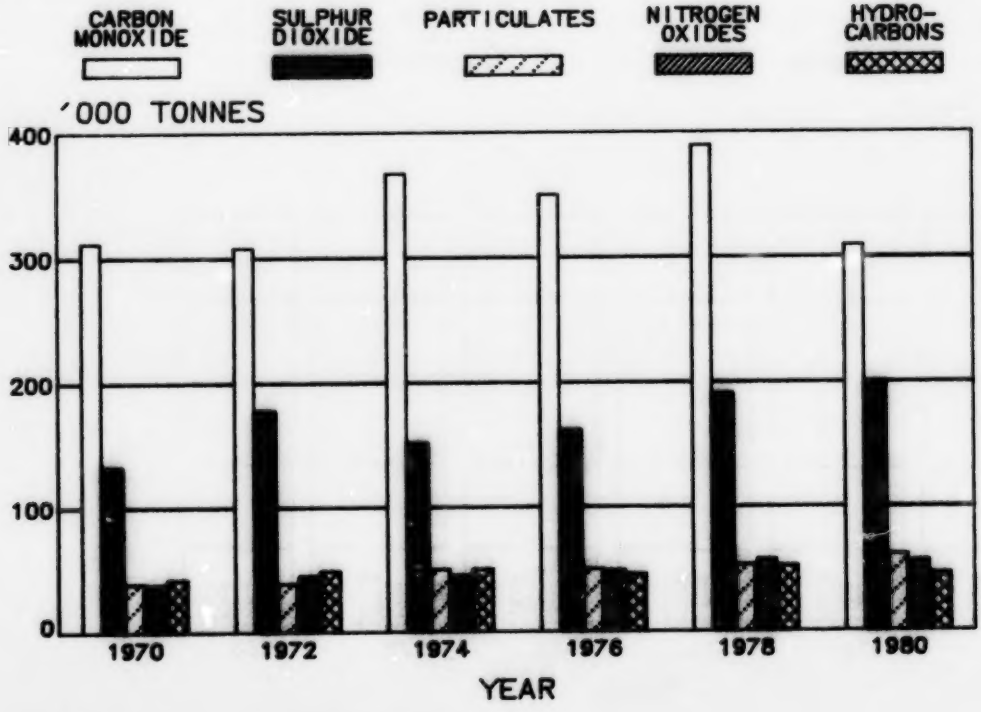

FIGURE B-4 NEW BRUNSWICK

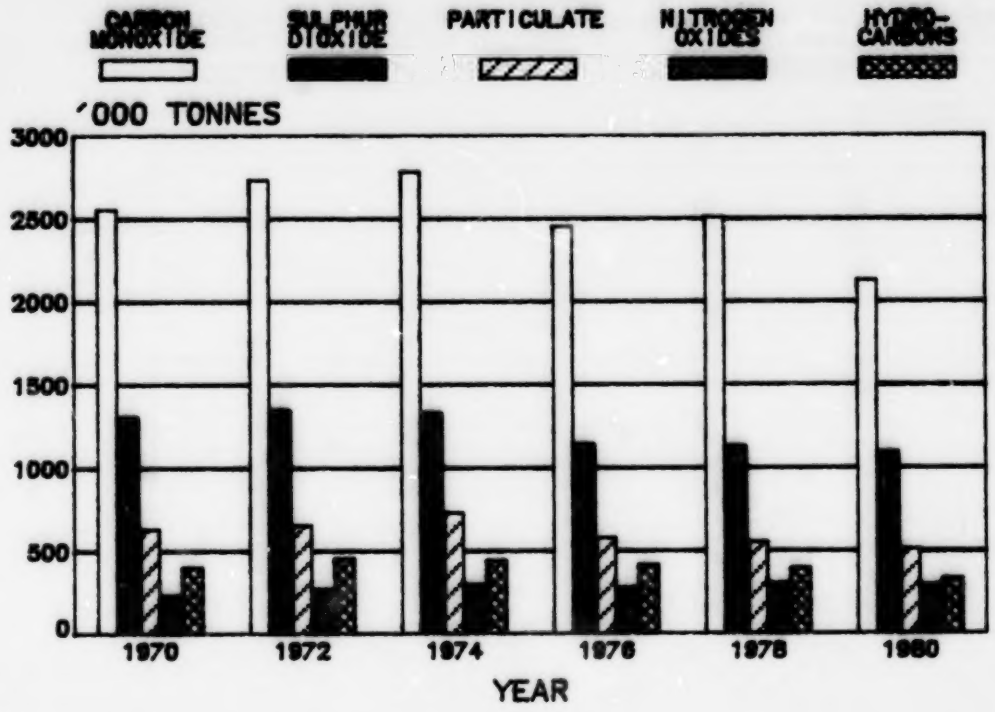

FIGURE B-5 QUEBEC

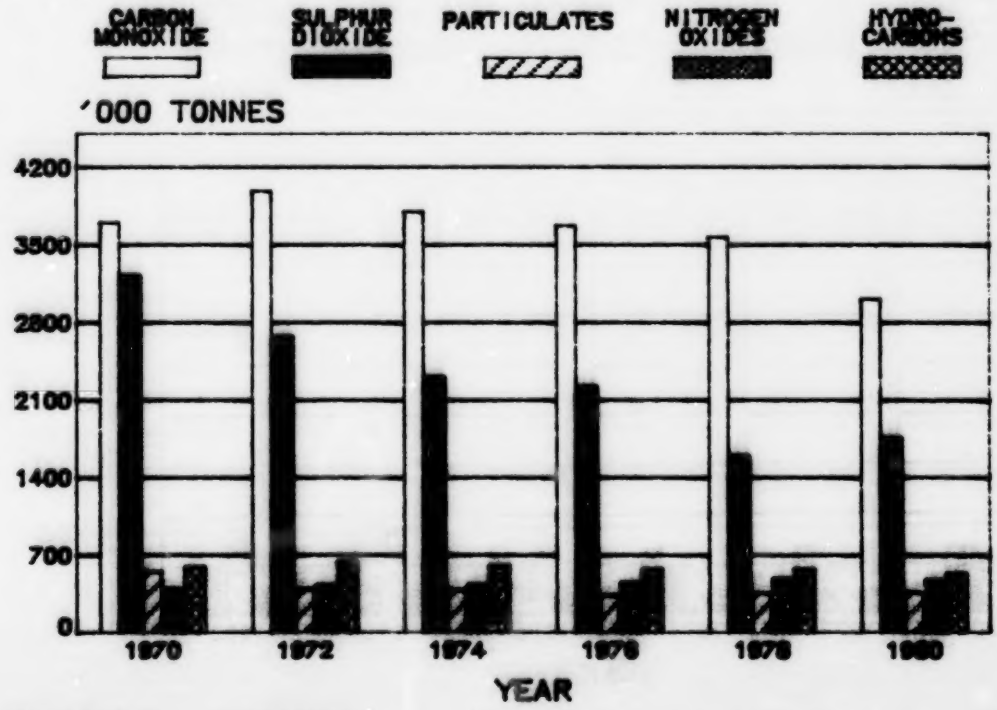

FIGURE B-6 ONTARIO

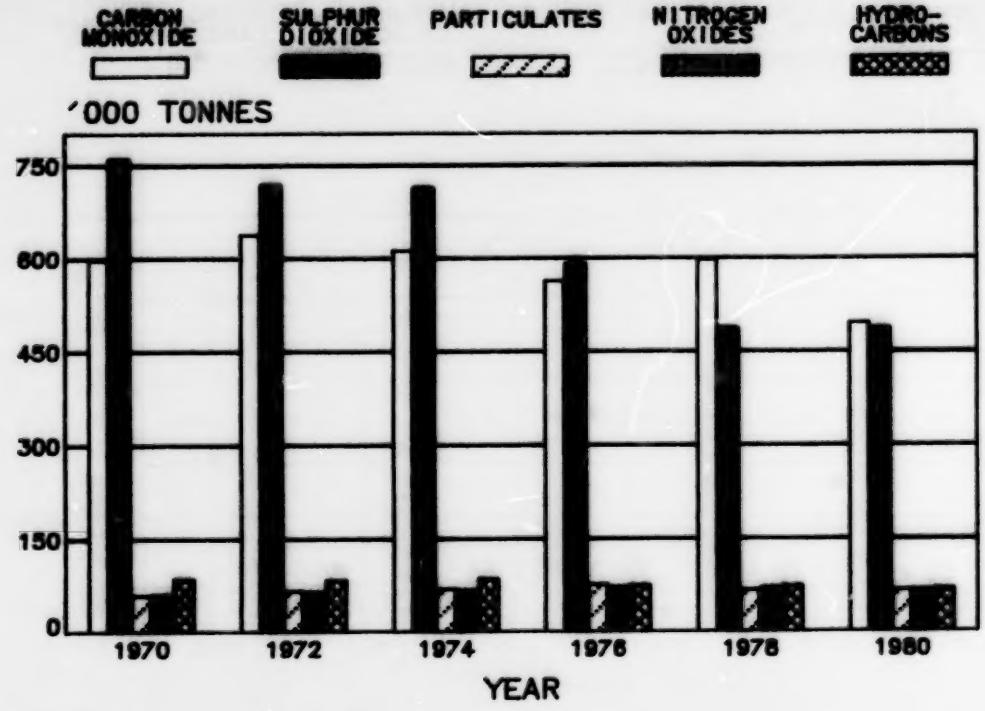

FIGURE B-7 MANITOBA

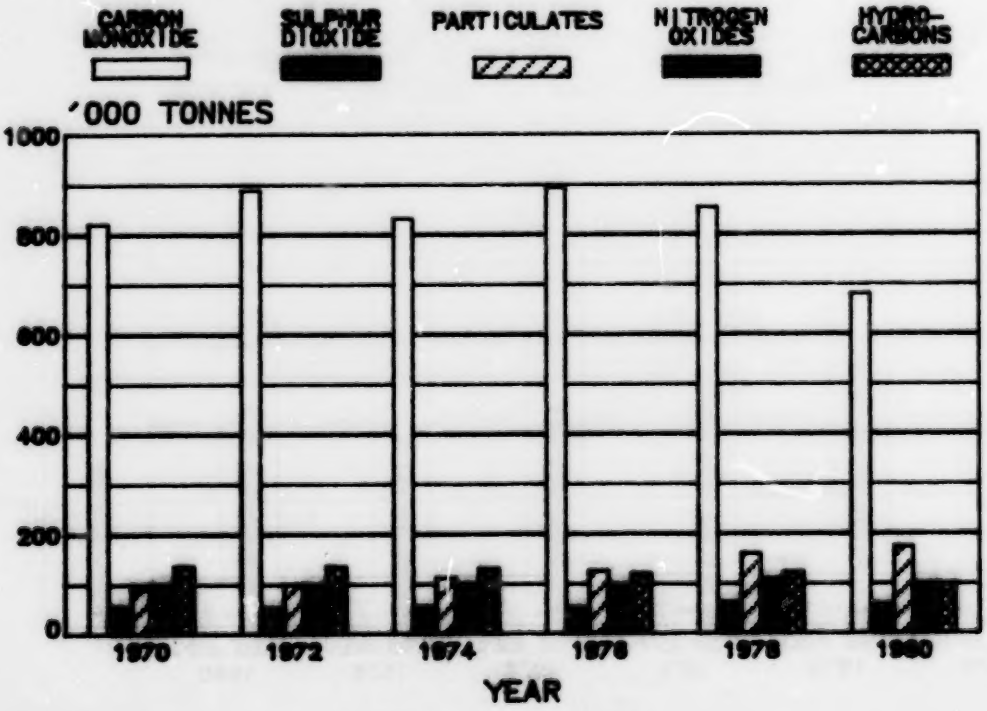

FIGURE B-8 SASKATCHEWAN

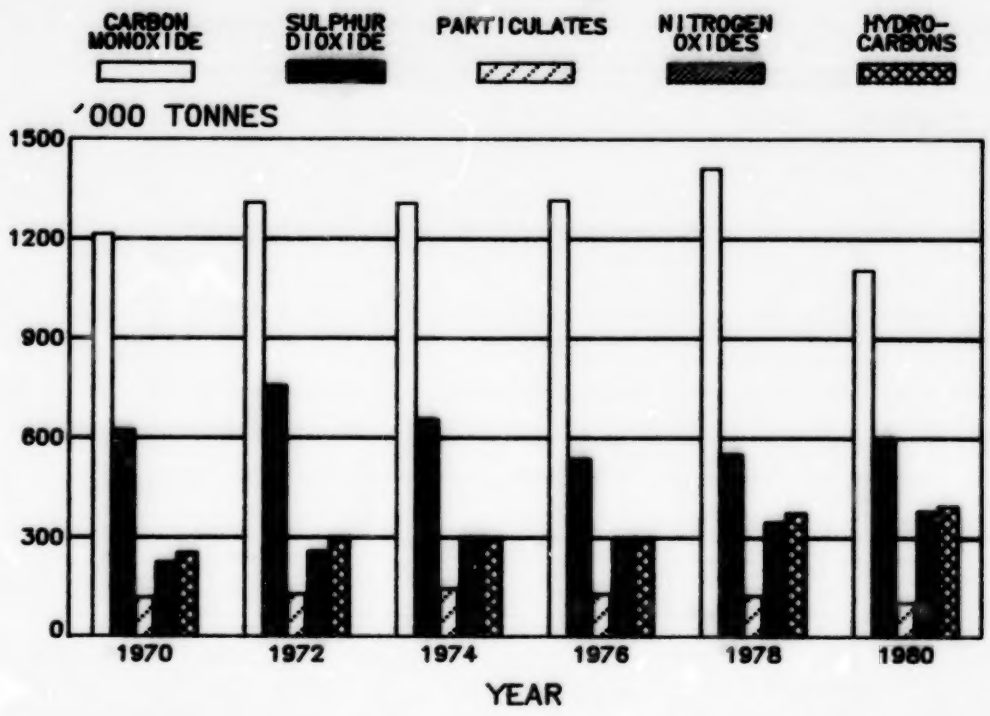

FIGURE B-9 ALBERTA

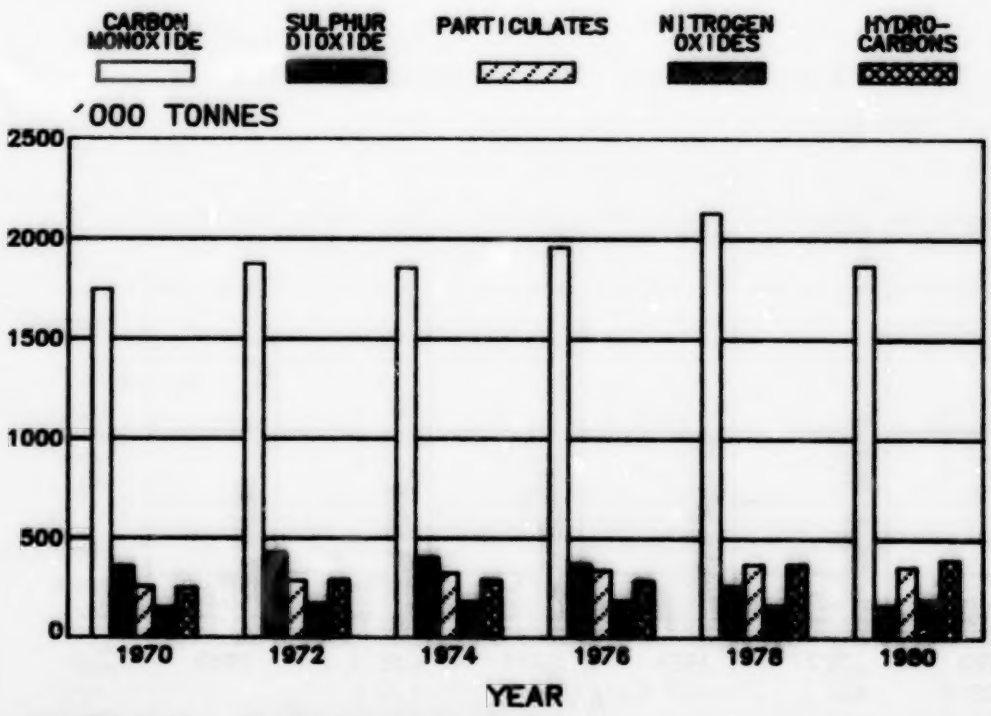

FIGURE B-10 BRITISH COLUMBIA

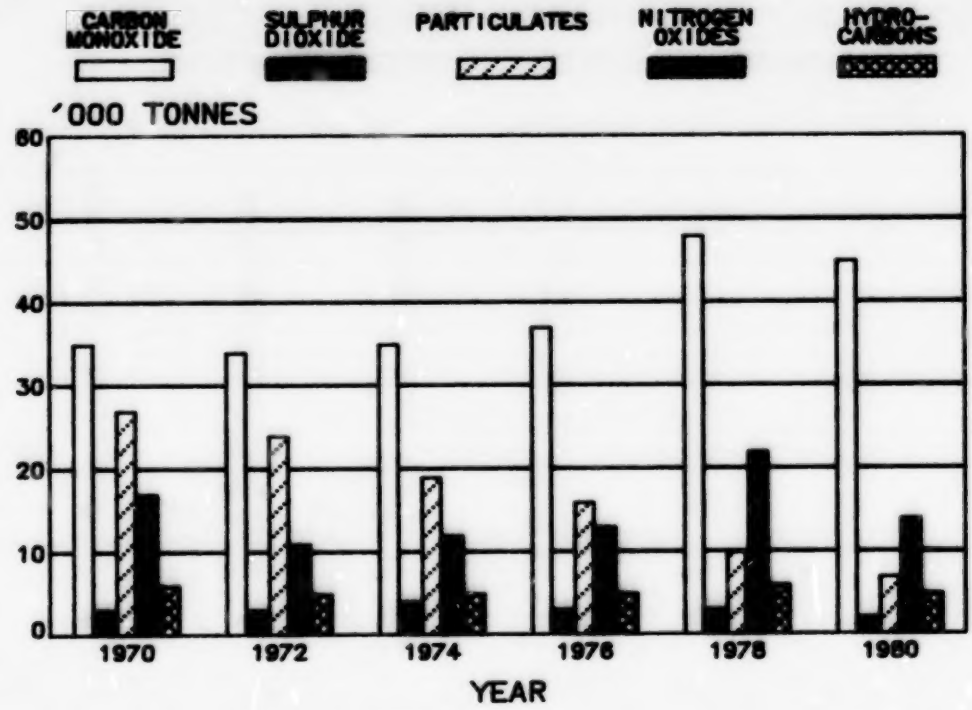

FIGURE B-11 NORTHWEST TERRITORIES

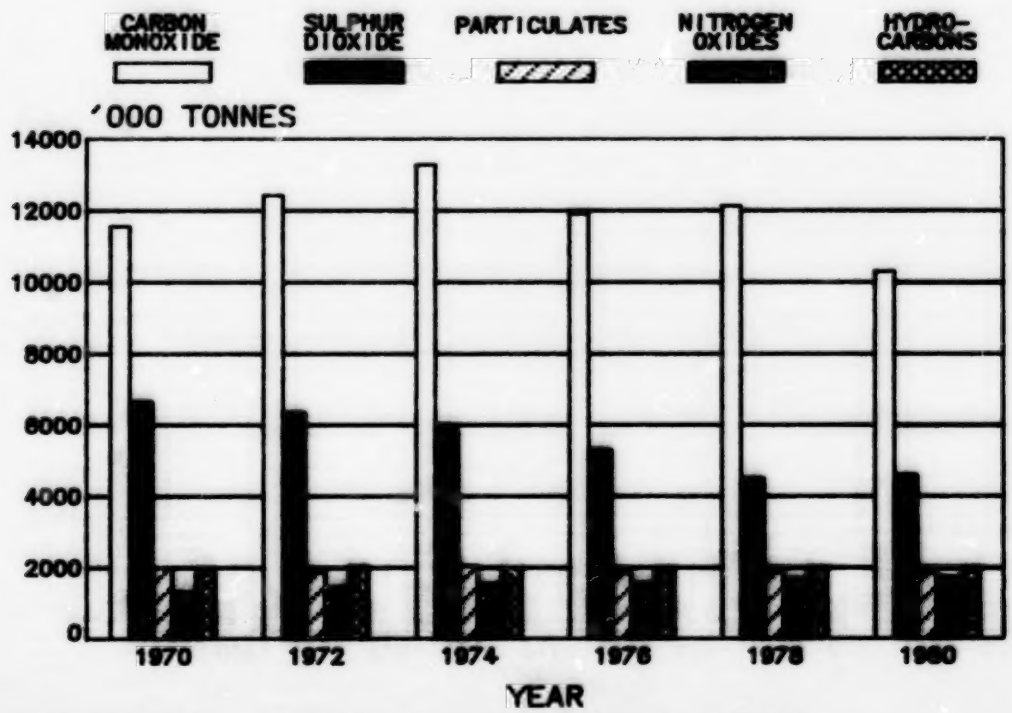

FIGURE B-12 NATIONAL EMISSIONS TRENDS - CANADA

TABLE B-1 PROVINCIAL EMISSION TRENDS (x 10^3 t)

	1970	1972	1974	1976	1978	1980
Newfoundland						
Particulate	123	104	122	112	80	107
SO_2	54	40	68	53	53	58
NO_2	27	27	31	29	27	32
CO	165	190	211	200	168	179
HC	23	29	38	35	24	25
Prince Edward Island						
Particulate	4	4	4	3	3	4
SO_2	9	10	10	9	6	4
NO_2	6	6	7	8	6	6
CO	51	54	55	53	53	52
HC	7	8	7	7	7	6
Nova Scotia						
Particulate	87	75	82	69	74	83
SO_2	144	163	170	171	175	189
NO_2	55	63	67	78	64	74
CO	356	409	425	403	390	350
HC	59	74	73	72	69	64
New Brunswick						
Particulate	40	40	51	51	54	62
SO_2	133	178	152	162	191	198
NO_2	39	46	46	50	58	57
CO	313	308	368	351	390	310
HC	43	50	51	47	52	45
Quebec						
Particulate	638	663	736	584	561	518
SO_2	1 309	1 351	1 335	1 145	1 131	1 096
NO_2	238	276	302	283	306	297
CO	2 561	2 738	2 788	2 458	2 516	2 133
HC	406	461	447	421	401	338
Ontario						
Particulate	566	411	401	347	370	377
SO_2	3 226	2 673	2 311	2 225	1 595	1 739
NO_2	409	443	445	466	500	487
CO	3 714	3 996	3 811	3 684	3 583	3 023
HC	605	653	616	584	588	545

TABLE B-1 PROVINCIAL EMISSION TRENDS (x 10^3 t) (Cont'd)

	1970	1972	1974	1976	1978	1980
Manitoba						
Particulate	61	68	71	78	69	69
SO_2	760	719	714	591	487	487
NO_2	62	67	70	74	73	69
CO	599	639	614	565	599	497
HC	87	85	86	77	75	67
Saskatchewan						
Particulate	93	102	114	128	162	176
SO_2	56	52	55	53	63	59
NO_2	90	96	96	101	110	98
CO	823	891	834	896	856	682
HC	138	137	133	122	125	102
Alberta						
Particulate	123	133	149	134	129	108
SO_2	623	757	656	536	551	599
NO_2	228	262	294	291	349	384
CO	1 217	1 312	1 311	1 320	1 416	1 110
HC	257	295	296	295	374	388
British Columbia						
Particulate	264	293	329	345	377	363
SO_2	359	428	404	371	260	164
NO_2	156	175	185	191	169	199
CO	1 752	1 879	1 861	1 963	2 134	1 873
HC	241	272	266	255	273	249
Territories						
Particulate	27	24	19	16	10	7
SO_2	3	3	4	3	3	2
NO_2	17	11	12	13	22	14
CO	35	34	35	37	48	45
HC	6	5	4	4	6	5

NOTE: emissions from forest fires not included

TABLE B-2 DISTRIBUTION OF NATIONAL EMISSIONS BY CATEGORY (x 10^3 t)

Category	1970	1980
Particulate		
Industrial	1 426	1 203
Fuel combustion	355	341
Transportation	69	95
Incineration	18	31
Miscellaneous	159	204
SO_2		
Industrial	5 045	3 092
Fuel combustion	1 549	1 385
Transportation	84	137
Incineration	-	-
Miscellaneous	-	-
NO_2		
Industrial	32	49
Fuel combustion	498	595
Transportation	792	1 077
Incineration	2	3
Miscellaneous	14	18
HC		
Industrial	364	569
Fuel combustion	56	58
Transportation	1 066	794
Incineration	18	30
Miscellaneous	369	484
CO		
Industrial	697	625
Fuel combustion	438	479
Transportation	9 429	7 828
Incineration	211	358
Miscellaneous	811	1 041

APPENDIX C
OPEN SOURCE EMISSIONS

APPENDIX C - OPEN SOURCE EMISSIONS

Emission inventories for anthropogenic sources generally include conventional area sources and point sources. A third significant category of anthropogenic emission sources have not traditionally been included in inventories and are known as open sources. Open sources, in the context of this study are defined as sources which emit air contaminants over large geographical areas primarily in a stationary non-point manner, which are diffuse in nature and cannot be controlled through enclosures or ducting. Sectors classified by Environment Canada as open sources include: agricultural tilling and wind erosion; construction sites; wind erosion of tailing piles; paved and unpaved roads; forest fires; and landfills.

Open sources are receiving increased attention, especially in the United States, since the analysis of the particulate matter from ambient TSP (total suspended particulate) samplers revealed that, at many sampling locations, the particles were originating from non-industrial sources (100,101). Further investigations indicated that some matter captured on filters taken from total suspended particulate samplers located in major cities was essentially crusted mineral matter and/or soil-like material. This analysis of emissions from open sources was therefore prepared to give an initial understanding of the origin of the soil-like material collected with total suspended particulate samplers and to indicate the contribution of open sources to the total atmospheric emission burden.

The reported emissions from open sources were calculated based on the best available inventory techniques (101). To date, published research in this area is limited. Moreover, the difficulty in measuring emission rates from open sources is by far more difficult than from point sources. The emission estimates, therefore, are preliminary, but it is unlikely they are incorrect by as much as an order of magnitude (102). It can also be said with certainty that the emissions from these sources exceed the particulate emissions from point sources.

The estimated emissions are very large and account for more than 90% of the total anthropogenic particulate emissions (Table C-1). However, their impact on air quality is not well known (103). It seems unlikely that open sources would influence measured ambient TSP levels in urban areas as much as emissions from conventional sources. In addition, open sources tend to emit larger particles than most point sources. Also, the emissions are generated mainly in rural areas. Impact on population centres would depend upon particle transport and relative toxicities, which have not been well established.

TABLE C-1 EMISSIONS FROM OPEN SOURCES, 1980

Province	Particulate Emissions (kt)							Emissions (kt)				
	Roads		Agricultural Wind Erosion and Tilling	Construction Sites	Tailing Piles	Forest Fires	Total	Forest Fires			Landfills HC	Total HC
	Paved	Unpaved						NO_x	CO	HC		
Newfoundland	17	127	1	192	1	2	340	1	2	1	45	46
Prince Edward Island	5	28	7	54	-	1	95	Neg*	1	Neg*	10	10
Nova Scotia	33	581	5	277	Neg*	2	898	1	2	1	66	67
New Brunswick	30	274	7	427	1	5	744	1	5	1	54	55
Quebec	212	1 521	85	4 359	6	52	6 235	1	56	8	488	496
Ontario	322	4 339	563	3 094	10	925	9 253	25	986	148	660	808
Manitoba	33	1 845	282	377	5	895	3 437	24	954	143	80	223
Saskatchewan	36	3 885	2 420	506	15	2 226	9 088	59	2 374	356	74	430
Alberta	88	6 277	2 299	3 087	2	1 524	13 277	41	1 626	244	155	399
British Columbia	144	1 178	79	1 888	18	108	3 415	3	115	17	199	216
Yukon/Northwest Territories	1	215	Neg*	-	5	2 220	2 441	59	2 368	355	5	360
CANADA	921	20 270	5 748	14 261	63	7 960	49 223	215	8 489	1 274	1 836	3 109

Neg* - Negligible

Agricultural tilling emissions were calculated by an equation using numerous variables such as: soil silt content; implement speed; climatic factor; acreage of harvested land; and number of tillings. These values were available from several sources: Agriculture Canada (104), Statistics Canada (105), Environment Canada (106) and other literature (107 to 109). Agricultural wind erosion emissions were far less tangible because of the complexity of the relationship between different variables. In some cases, the data for these variables were not available for Canada. In order to compute the emissions, an average emission factor for U.S. soil bordering Canadian provinces was used with the acreage of harvested cropland taken from Statistics Canada data (105).

Emissions due to construction activity were estimated using a relationship derived in a U.S. study (101). Emissions from different types of construction activities were estimated using construction expenditures taken from Statistics Canada (110), average duration and activity levels of construction taken also from the U.S. study (101).

Emission from tailings piles were a function of climate and acreage of tailings. The emission factor was taken from a U.S. study (101), climatological data was available internally (106) and the acreage of the tailings ponds was determined by Energy, Mines and Resources (111).

For computing emissions from vehicles travelling on paved roads, an emission factor taken from a U.S. EPA publication (112) was used. The only available data on vehicle miles travelled by road type was obtained from the province of Saskatchewan (113). These statistics were then applied to the other provinces, taking into consideration the provincial mileages for each type of road (116), based on provincial lengths by road type.

Emissions from unpaved roads were sub-divided into three categories; earth roads, gravel roads, and treated gravel roads. Emissions from treated gravel roads were calculated in the same manner as for gravel roads except that a control of 50% was applied to the emissions (115). Several variables affecting emissions from unpaved roads were considered: silt content of roads; vehicle speed; and number of dry days with no snow cover. Silt content of earth roads was obtained from information provided by Agriculture Canada (104). For gravel roads, a value of 12% was taken for the silt content based on data from a U.S. EPA publication (36). Vehicle speed was taken as 30 mph for gravel roads and 25 mph for earth roads (108). The number of dry days was calculated using information provided by the Atmospheric Environmental Service (106) for various representative stations in Canada. Emission factors were applied to total vehicle miles

travelled by road type which were calculated using vehicle registrations (114) and mileage travelled by road type estimated from the Saskatchewan Highway report (113).

Information on the acreage of forest burned for determining the emissions from forest fires was obtained from the National Forest Fire Research Institute (117). A conversion factor of 22 t/ha of dry wood was used for the emission computations (117). The emission factors were obtained from the literature (36,118).

Emission strengths from landfills are highly dependent on variables such as: nature of materials buried; temperature; and moisture. A study used for the 1978 nationwide inventory indicated annual emission rates of 0.07 to 11.8 kg of methane per tonne of buried refuse (124). The accepted emission rate in 1978 was based on an internal study (70). A more recent study (125) accepted an emission rate of 7.36 kg/tonne of buried refuse per year as reported in a research paper (126). The quantity of refuse buried in Ontario was taken from this same study (125). An emission factor based on the acreage of landfill sites was then developed to calculate the emissions for the other provinces based on their respective acreage of landfill sites.

APPENDIX D

1980 FUEL COMBUSTION EMISSIONS BY MAJOR FUEL TYPE

APPPENDIX D - 1980 FUEL COMBUSTION EMISSIONS BY MAJOR FUEL TYPE

TABLE D-1 COAL USE EMISSIONS BY PROVINCE, 1980

	Emissions (t)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Newfoundland	19	148	3	19	86
Prince Edward Island	106	517	16	106	477
Nova Scotia	8 369	69 011	20 950	824	3 691
New Brunswick	8 823	56 897	3 939	64	353
Quebec	3 505	28 480	4 089	32	1 461
Ontario	28 658	420 185	102 651	1 648	6 717
Manitoba	6 363	4 778	2 456	515	592
Saskatchewan	90 272	34 017	9 093	865	3 536
Alberta	15 693	66 550	40 884	2 379	9 291
British Columbia	1 429	557	333	4	124
Yukon, Northwest Territories	-	-	-	-	-
CANADA	163 237	681 140	184 414	6 456	26 328

* expressed as SO_2
** expressed as NO_2

TABLE D-2 LIGHT FUEL OIL USE EMISSIONS BY PROVINCE, 1980

	Emissions (t)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Newfoundland	122	2 525	991	91	267
Prince Edward Island	43	910	357	32	97
Nova Scotia	293	5 915	2 311	242	627
New Brunswick	212	9 708	1 709	169	442
Quebec	1 533	30 255	12 196	1 219	3 297
Ontario	1 400	24 840	11 634	1 171	2 919
Manitoba	45	687	367	37	96
Saskatchewan	55	818	434	45	116
Alberta	30	471	257	16	66
British Columbia	226	3 338	1 766	191	471
Yukon, Northwest Territories	28	470	261	13	67
CANADA	3 987	79 937	32 283	3 226	8 465

* expressed as SO_2
** expressed as NO_2

TABLE D-3 HEAVY FUEL OIL USE EMISSIONS BY PROVINCE, 1980

	Emissions (t)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Newfoundland	3 388	45 738	5 762	163	604
Prince Edward Island	199	2 634	509	9	41
Nova Scotia	6 479	84 173	13 293	238	967
New Brunswick	7 080	102 740	17 867	320	1 368
Quebec	15 407	193 804	29 006	878	2 769
Ontario	8 155	60 868	15 443	468	1 476
Manitoba	229	1 687	431	13	41
Saskatchewan	225	1 672	438	12	41
Alberta	44	323	83	2	8
British Columbia	2 984	21 998	5 619	170	536
Yukon, Northwest Territories	21	153	39	2	4
CANADA	44 211	515 790	88 490	2 275	7 855

* expressed as SO_2
** expressed as NO_2

TABLE D-4 NATURAL GAS USE EMISSIONS BY PROVINCE, 1980

	Emissions (t)				
	Particulate Matter	Sulphur Oxides*	Nitrogen Oxides**	Hydro-carbons	Carbon Monoxide
Newfoundland	-	-	-	-	-
Prince Edward Island	-	-	-	-	-
Nova Scotia	-	-	-	-	-
New Brunswick	-	-	3	-	1
Quebec	140	28	5 882	305	1 635
Ontario	830	168	34 478	1 907	9 724
Manitoba	85	17	3 151	211	998
Saskatchewan	170	25	5 710	283	1 460
Alberta	724	352	30 102	1 171	5 931
British Columbia	206	42	9 313	466	2 418
Yukon, Northwest Territories	-	-	13	1	4
CANADA	2 155	632	88 652	4 344	22 171

* expressed as SO_2
** expressed as NO_2

MAPS NOT

FILMED

CARTES

OMISES